

# Project Summary

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U.S Department of Energy

Solar Decathlon 2023

Build Competition



## Project Overview

The Canopy, located in Boulder, CO is an affordable and energy independent home with an effort to move faster to decarbonize our buildings past Net-Zero Energy. The project started with a partnership with Habitat for Humanity and the City of Boulder to take their base design and make it Net-Zero Energy without breaking the budget. Through the process we focused on a high-performance envelope that was low in embodied carbon, easy to construct with volunteer labor, and repeatable. With the increasing energy inequality especially for low-income families, we wanted to build a home with diversified energy storage that was resilient to changes in energy prices, extreme weather events, and government policies. The home will be one of the first grid-connected homes to produce, store, and use “Green Hydrogen” to power the home energy demand without the need for an electric grid or intensive Li-Ion Batteries. In doing so the home will save approximately 4.5 Metric Tons of CO<sub>2</sub> or the equivalency of removing a 24 MPG car off the road each year.



## Design Philosophy

As we transition our energy needs away from fuel towards electricity, a global shift of how we interact and use energy is needed. At the same time, energy volatility, extreme weather events, and general unrest are broadening the gap between affordable housing and green energy equality. At the crux of the problem is the mismatch between affordable construction and net-zero energy with the building and homeowner having different incentives.

Although practical, traditional net-zero energy relies on the grid as an infinite battery. Consolidating our energy needs to electricity, combined with the intermittent of renewables, requires significant upgrades and solutions and has adverse effects on grid operators. They must ramp up and slow down power generation on the grid suddenly to accommodate the mismatch between supply and demand.

Our solution to this challenge is energy storage in the form of Green Hydrogen and Thermal Storage. During the day, when the sun is shining, a rooftop solar array provides power to meet the home's energy demand. When there is excess energy, instead of sending it to the grid or storing it in a battery, our energy management system can produce green hydrogen, store it in our thermal battery for later use in heating water, or run our heat pump to charge PCM (Phase Change Material).

To meet the electrical needs of a home, we use a Hydrogen Energy System. This system converts a small amount of water into hydrogen and oxygen through electrolysis. The hydrogen is then safely stored in low compression tanks outside the home, while the oxygen is released harmlessly into the atmosphere.

At night, when there is no power from the solar system, the Hydrogen Energy System provides power to the home through a fuel cell. The fuel cell combines hydrogen with oxygen from the air to create water vapor, which in turn generates electrical energy. Hydrogen provides a unique benefit in that it allows up to ~56kWh of seasonal energy storage, which can help dampen the excess energy needed in the winter. This equates to approximately 5 days of the home's energy demand.

To meet the demand for hot water, we use a PCM Thermal Battery, which stores heat instead of electricity. Excess energy from our solar system can be used to melt PCM into a liquid, storing compact latent heat that can be used later to heat water on demand. The thermal battery is one-third the size of its equivalent water tank, which allows it to be placed within the living space next to where it is needed, reducing the time, water, and energy typically wasted. Furthermore, its compact size provides high energy density, allowing us to store excess energy for when there is no sun.

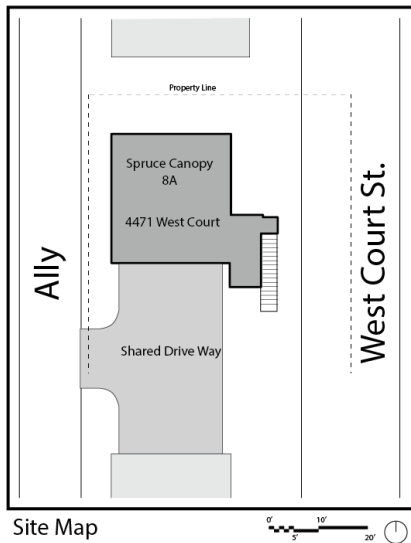
Finally, we store around ~17kwh or 7 hours of our average heating load within our walls in the form of PCM. Metallic sheets of aqueous salt PCM is placed behind our drywall. The PCM helps to shift the heating and cooling load and dampen the peaks when there are drastic temperature changes. Rather than just resisting heat flux through the wall, it prevents and stores that energy to be used later.

With all this energy storage we wanted a way for the homeowner to be aware of how the energy in the home was being used, without the need for them to control it. We wanted to build a home that pushed the bounds of what it meant to be sustainable, what it means to be affordable, and past net zero energy towards energy independence.



## Construction Site Details

Our building site is located at 4471 West Court 80304 Boulder, Colorado next to Foothills Community Park.



The community surrounding the home is the Ponderosa Mobile Home Park. This community consists mostly of low-income Boulder residents. In the past decade, it has experienced catastrophic flooding in 2013 and rising crime rates. In response, the City of Boulder is converting the park to permanent units. A row of empty lots made it possible for new units to be constructed before demoing any trailers. Thus, throughout the project, not a single resident will be temporarily without residence. Our home will be built in one of the existing empty lots and will be just the second home in the project completed. The site also happens to lie in a floodplain, yet another reason for the above-garage unit.

The City of Boulder oversees the revitalization project and owns the land we are building on. They have authority over the site and our team and design adhere to the City of Boulder code including affordable housing and livability standards.

## Construction Partners

Central to our integrated design process was connecting with industry partners to get feedback, exchange ideas, and shed new perspectives. We were fortunate to follow in the footsteps of the University of Colorado Boulder's 2020 team (SPARC House), who had some pre-established industry partners to work with. Through the design and construction stages we have networked, developed wonderful partnerships, and gained incredible insight into the construction process.

Our two primary partners are Flatirons, an affiliate of Habitat for Humanity (H4H), and the City of Boulder. The City of Boulder and H4H have a partnership to redevelop the 48 home mobile park, into an affordable and revitalized community. Habitat For Humanity is the general contractor for the entire revitalization project and their volunteering build model and affinity for donations allows the City of Boulder to keep costs low. After all, this is an affordable housing development. We are also partnered with the City of Boulder but work most closely with Habitat.

When we joined the project, The City of Boulder had already hired a local architecture firm to design several base designs that would be replicated throughout the park. Our agreement with the city and Habitat was that we would take one of the base case designs and modify it to make it net zero. As long as we justified the changes we made and the design adhered to the community design standards, we were given free reign.

We received help from many other local industry partners as well. Caddis architecture worked alongside us as we updated their design. Other firms also donated their time to act as advisors and in some cases, we hired them to produce stamped plans for submission to the city for permitting.

Countless other sponsors contributed in the form of donated or reduced-cost equipment. Others contributed to our project in the form of monetary donations. Firms such as Shell Energy are eager to invest in sustainability projects as they begin to look into solutions for themselves.

## Future Plans

Due to numerous construction delays, our team does not have a completed home at this time. As a result, we have not yet held our public exhibition. We originally planned on getting the house dried-in and holding our exhibition without internal finishing and with temporary appliance installs. However, construction did not progress enough for this to become a possibility.

Instead, our community event will be put on once our home has a certificate of occupancy later this year. The benefit of this is that the home will be fully completed, and the event will have the feel of an open house rather than a construction party. As we are some time away from holding the public exhibit, we have held off on planning details in favor of focusing on construction.

## Marketing and Outreach

Our team has had significant success marketing this project so far. Co-leads Kyle and Wes guest starred on a one-hour podcast episode with Build Tank Inc just down the road from our university. In the episode, they talk in-depth about design and what sets it apart in the building industry. One of our sponsors, Mission Zero, filmed a promotional video with us highlighting why our project is important in the context of the climate change crisis. A few other articles have been done about our team by our university promoting the groundbreaking home design.

The delayed schedule put our media push on hold for some time, but we are currently revamping our efforts as construction is picking up. We are currently in touch with our university's media relations who is on standby to write a wrap-up article. This piece will highlight the journey of the project and the triumph of the completed home. We are planning to have folks out to the site to take pictures and conduct interviews once construction is a little further along. After that, the article and photos will be rolled out through most of CU's channels and local media outlets.

Co-leads Paul Neumann and Wes Mcevoy were also recently selected to travel to Minneapolis for the International Getting to Zero Conference. They will present the never-before-seen home design as closing speakers on

The team website has also been updated and is currently live. The website sees significant traffic and promotes the current project as well as those past.

[Build Tank Build Cast Episode](#)

[Mission Zero video](#)

[Groundbreaking Article](#)

[Fundraising Article](#)

[Promotional Article](#)

[Cusolardecathlon.com](#)