



TEAM ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
ILLINOIS SOLAR DECATHLON

RENU HOUSE

A RENEWABLE, ECONOMICAL,
NOURISHING, & UNIVERSAL HOME

DURABILITY AND RESILIENCE

1. INTRODUCTION

Illinois Solar Decathlon is an interdisciplinary registered student organization at the University of Illinois at Urbana-Champaign seeking to lead innovation in design and construction to advance towards an environmentally sustainable future. We are thrilled to present our latest project, RENU House.

RENU House is a 1,510 SF energy net-zero home. RENU represents the four guiding principles of our design and construction processes: Renewable, Economical, Nourishing, and Universal.



RENEWABLE

The most important feature of the project is energy net-zero status, but we have also striven to reduce the effect on the surrounding environment in every other aspect of the home.



ECONOMICAL

Sustainable developments must be financially feasible to be adopted. We have prioritized cost efficiency in every design choice to ensure the home remains affordable for our target clients.



NOURISHING

The design seeks to encourage fulfilling lifestyles by prioritizing accessibility for all abilities and emphasizing the mental and physical health of occupants.



UNIVERSAL

This design can be replicated in similar small-town markets across the United States, potentially bringing sustainable innovation to communities throughout America.

RENU House is nestled in the village of Rantoul, Illinois, a town of roughly 12,000 people fifteen miles north of the University of Illinois at Urbana-Champaign. Illinois Solar Decathlon has partnered with the Village of Rantoul Urban Planning Committee and the local Champaign County chapter of Habitat for Humanity for the build, consistently communicating with local stakeholders to ensure the home meets the needs of the occupants while effectively integrating into the small-town community.

RENU House was designed as a family residence, and can accommodate a diverse range of family dynamics such as a single parent or multigenerational household. Upon completion of the Department of Energy Solar Decathlon competition, the home will be fully donated to a local Habitat for Humanity family in need: Elonda, a single mother and intermittent wheelchair user, and her daughter, Monae, who is pregnant with her first child.



2. PHOTOVOLTAIC AND ELECTRICAL

To avoid high maintenance costs and potential equipment failure, our panels are rated to withstand 5400 Pa front load and 3600 Pa back load. In other words, our solar panels can sustain roughly 210.3 mph wind speed on the front end, which is especially important for us to consider in our selection since Illinois is prone to tornadoes averaging to 200 mph. Another reason why we chose Mission Solar is because of how reliable the panels are. By code, our panels are tested to UL 61730 and IEC standards since safety is a huge consideration in design. Our panel is also potential induced degradation (PID) and salt mist corrosion resistant, resulting in minimized solar power output loss and increased longevity. As a result, not only do we want to save our H4H family from large future costs, but also keep them safe in case of natural disaster events.

With the increase of DERs (distributed energy resources) injected into the power grids, many utility infrastructure will not be able to keep up with the rate that politicians across the nation are demanding reliance on renewable energy sources. As utilities work towards upgrading power grids to support two-way power flow, the need for customer cooperation to work around peak demand curves will be a necessity in the future. The load shedding sub contest illustrates the future of how we as customers can work around load curves. Our system is equipped to automatically shed loads remotely on an app, and extract from backup battery storage if needed to power other operating loads outside of the critical load panel. Not only can we utilize this operation if a power outage occurs, but we can also utilize it in the case of utility load calls.

During the event of a power outage or utility load call, the 10kWh battery will allow for critical loads such as the heating and cooling units, ventilation units, and essential appliances and lighting to remain in operation. According to Triton Solar, a 10 kWh battery can power a house up to 8 hours assuming 1 kWh is used per hour. As a result, this estimate shows that our 10 kWh battery can power a third of a day, which is essentially 8 hours on average. The estimated consumption of the house is 1.34kW/hr, and with a 10kWh battery, it can power the home for about 7.5 hours. Thus, this result agrees with Triton Solar and we can assume that our battery can last the house at least 8 hours of power during any grid islanding or shedding scenarios.

With the low income family narrative in mind, we originally designed our system without a battery for a more economical solution due to the low probability of a blackout in Champaign county. However, we later on decided to prioritize resiliency of our power supply and extended the system to a grid-tied battery backup solar system to ensure that our residents will have power at all times considering the mother can be wheelchair bound and the daughter is expecting a newborn. We would not want to add any additional stress of having no power considering their situation and importance to stay safe. The incorporation of market leading technologies like the Leviton Smart Load Center and SolarEdge Backup Interface Unit aim to increase efficiency as well as occupant ease of use and ease of installation.

The Leviton Smart Load Center coupled with smart circuit breakers adds to the resilience of the home's overall electrical system since the circuit breakers will automatically trip if loads exceed their current rating and alert the homeowner as to what changes have occurred in the system. The circuit breakers are capable of operating within ranges of -40 to 185 degrees Fahrenheit without need of re-rating. The LEDs in the breakers remain lit even when a breaker is tripped to allow the homeowner to identify the fault that has occurred. The circuit breakers meet UL requirements and feature patented reset lockout technology. Working together with the backup battery and smart circuit breakers, the smart load center will ensure that power is still supplied to our critical loads of heating/cooling, ventilation, and main lighting even during power outages.

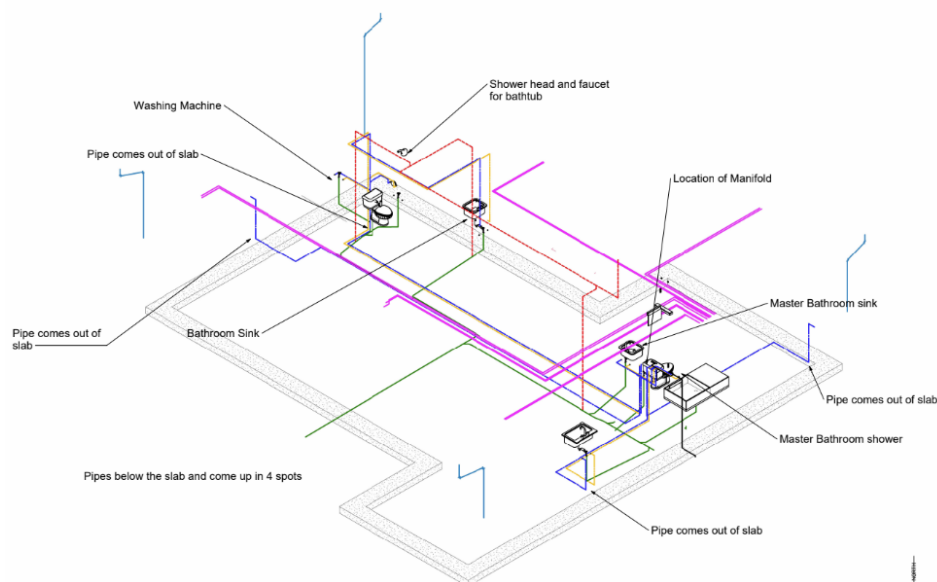


3. WATER

RENU house's water system design seeks to minimize maintenance needs while maximizing longevity, and ease of installation. Starting with the core of our system, our tankless electric water heater has double the lifespan of traditional tank heaters at an average of 20 years. Rather than being exposed to moisture at all times, this heater is less at risk to sediment buildup and corrosion damage, while also being easier to replace and install. They also have easily replaceable parts that can extend their usability by many more years.

The long-term performance of our plumbing system is further enhanced with PEX tubing that maintains an average lifespan of 50 years due to it being easy to maintain and less susceptible to corrosion - similar qualities seen in our water heater. Along with the ability to withstand temperatures as low as -40°F, PEX also has a higher resistance to breakage because it does not expand or contract as much when heated or cooled, and is less likely to develop leaks due to a reduced need for elbows and transition fittings.

Illinois, in particular, faces challenges when it comes to unpredictable weather patterns especially during the wintertime. To address this, we carefully designed our plumbing system to be able to withstand extreme temperatures and potential disasters by insulating the hot water lines with R34 insulation. In the event of a plumbing emergency, usually leakage, our PEX manifold provides the homeowners with a convenient way to turn off the water supply to individual fixtures or appliances without losing water service to other areas of the home, allowing them to continue on with their daily lives. Additionally, the supply lines for the child bathroom are securely located underneath the concrete slab to avoid environmental damage to the pipe material over time and even if the house experiences serious damage, these lines will continue to function.



Plumbing Design

The plumbing design integrates passive strategies by prioritizing the conservation and efficiency of water consumption through an optimal layout integrated into the structural and architectural design. The heater is optimally located in the MEP room between the kitchen and parent bathroom which



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serves to improve the efficiency of hot water delivery to the nearby fixtures - kitchen sink, bathroom sink, and shower. With the size of our heater, residents are also able to run both showers at 1.75 GPM each without exceeding the limit of the pump. Since the showers have higher flow rates than all our other fixtures, we can confidently say that the water heater will never be overdrawn.

4. HVAC

The Lunos system uses a ceramic core and this regenerative core is charged every 70 seconds, after which the fan reverses and the incoming air absorbs the stored heat on its way in. The ceramic core helps extend the durability of the ventilation system as well as aides in increasing energy efficiency owing to its properties.

Keeping in mind the clientele for our home coming from a lower income background, we wanted to make sure our H/AC and ventilation systems can stand the harsh weather of the midwest and function without needing constant maintenance. Our systems come equipped with certain protection to help with this.

- The Lunos units have exit grills with angled slants, to avoid rain water entering the system. They also come equipped with a bug screen to avoid insects entering and causing blockages
- A drip edge is also baked into the design for water to seep straight down instead of into the system



Lunos Ventilation Units

Focusing primarily on the occupant health aspect, a 2018 study found evidence that environmental pollutants can disrupt cytokine production. This is important to note, because newborns can't make enough on their own yet and get their cytokines from the mother's nourishment. Hence when pollutants from the environment throw off the balance of cytokines in milk, this can potentially harm the baby's immune system development. The Lunos e2 60s are fitted with Merv5 filters for this very reason. Moreover, they are washable and reusable. Thus the upgraded filtration system pushes for better air quality.



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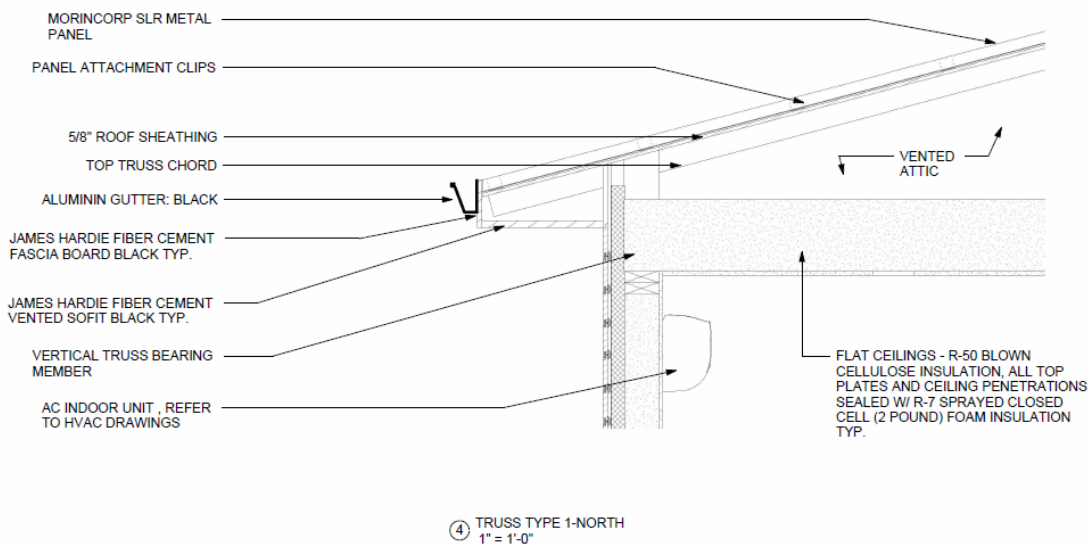
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5. MATERIALS

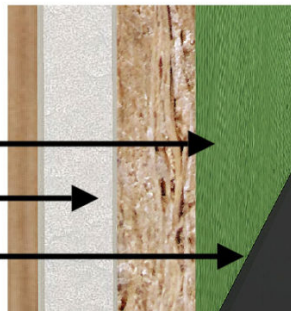
Throughout the architectural design and selection of materials of the home, performance and longevity were the constant considerations of every choice. With the busy life of a single parent in mind, simple, long lasting details and sturdy material choices were made to reduce construction difficulty and lower the risk of inconvenience and costly maintenance throughout the life of the home.



In the framing process of the home, the envelope design employs a highly innovative 3-1 ZIP panel to increase the energy efficiency of the home within the cold temperate climate of central Illinois. Applied using the same technique as OSB sheathing, the ZIP system packages R-10 insulation, the necessary structural diaphragm, and the vapor barrier into a single compact system. While the panel itself is more expensive than a standard sheet of OSB sheathing, the ease of construction, added performance, and consolidation of resources greatly outweigh the additional cost.

Zip System R Sheathing

1. OSB with WRB
2. 1/2" or 1" Polyiso
3. Zip Tape



With the ZIP sheathing, we chose to use sprayed cellulose insulation to fill the stud cavities and the meticulous application of spray foam to create an airtight seal. The cellulose allows for significantly



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better insulation due to its ability to reduce the amount of gaps that typical batts or rigid insulation leaves behind. Its tendency to conform around obstacles such as piping and wires contributes to its overall strength effectiveness in insulating the home. With harsh weather events like increased wind speed in central Illinois, the cellulose will allow the home to maintain its performance over time by providing advanced insulation and ultimately heightened energy conservation.

The roof is fitted with Morin Corp. single skin standing metal seam panels. The metal roof panels have a number of advantages, because the panels are cut to the length of the roof slope, there are no horizontal seams on the roof. This feature greatly reduces the potential for damage overtime from snow and rain. While more expensive, they are more durable, with a lifespan of 3-4 times that of a traditional asphalt roof making them better suited for intense wind storms and preventing the buildup of organic growth over time, leading to lower long-term maintenance and labor costs. Overall, the potential cost and headache of roof damage greatly outweighs the additional upfront cost of the metal standing seam system.

The rainscreen consists of MOSO® Bamboo X-treme® siding. The raw bamboo is put through a heat treatment process that increases the durability of the siding by elevating its stability, density, and hardness. This contributes to the decreased chance of long-term damage, such as warping and discoloration that traditional siding experiences as time goes on. Furthermore, it mitigates the need for the normal siding replacement cycle that many homeowners undergo as a result of deterioration. Another advantage of the bamboo siding is that it does not swell or shrink as a result of temperature changes compared to the ordinary vinyl material, which are very prevalent in the Rantoul area.

MOSO, a pioneer in the bamboo industry, holds multiple green building certifications including a Forest Stewardship Council Certification. The X-treme Bamboo siding on the RENU house is carbon positive as the carbon sequestered in the bamboo is greater than the amount used in getting each board to market. Additionally, the bamboo flooring complies with the strictest European and American VOC standards. Bolstering sustainable bamboo products will ideally expand their presence on the market and make standard vinyl siding and flooring less appealing because of their intense use of petrochemicals.



The mark of
responsible forestry
FSC® C002063



The window and doors for the home were sourced from Jeld-Wen which has a door manufacturing plant in the village of Rantoul. Our partnership with Jeld Wen allowed some of the components of the home to be manufactured just a few miles away from the site which is extremely rare in our globalized market. This lowers embodied energy from transportation and contributes to the economy of the local community. The windows, assembled a few hours North in Grand Rapids Michigan, have an energy efficient low-U factor and contain the optimal solar heat gain coefficient for our region. We opted for AuraLast pine for the frames of the windows because of their sustainable sourcing from renewable forest and the reduction of VOCs that would otherwise be released from typical vinyl window assemblies. Jeld-Wen also holds a number of forest sustainability certifications while managing its own sustainable forests. Throughout the design of the home we opted for wood materials because wood as a building product bolsters better forest management through market incentives.



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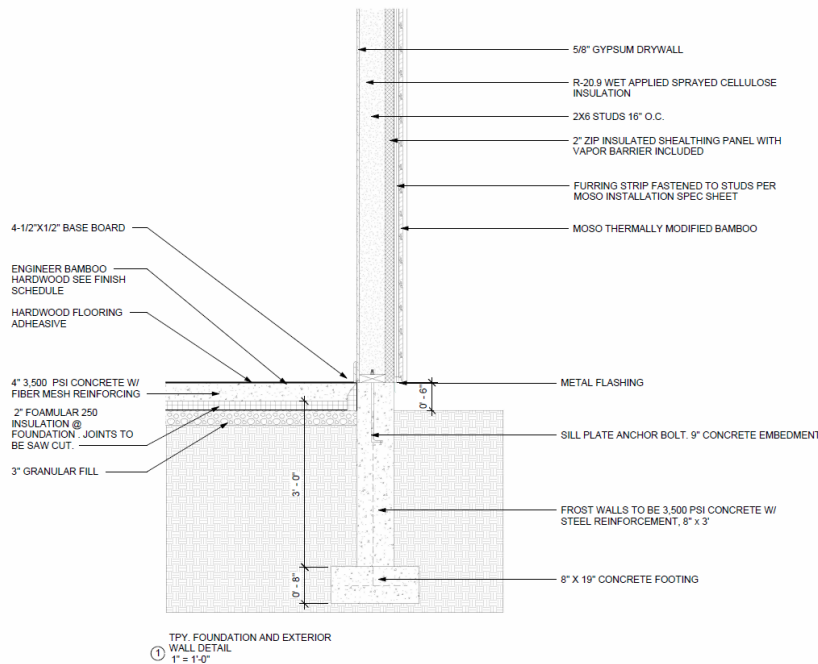
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Lastly, we chose a concrete foundation with a slab on grade design. This design will ensure the home reaches its full life span which is expected to be between 150 - 200 years with proper maintenance. Furthermore, the foundation design is stronger due to the uniform pour. This design is preferred due to its time and cost saving in construction. The home's foundation was poured above the water table and the floor elevation is about four feet above street level. This ensures that the home will not be affected by a 100 year flood as the area has experienced flooding in the past. This issue is important as we face climate change in the years ahead and more severe weather conditions.



6. OCCUPANT SAFETY



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The home has a privacy fence in the backyard connecting to neighboring fences, creating a private retreat for the family to enjoy the patio in privacy. The home itself utilizes casement windows as they can only be opened from the inside which prevents intruders from opening an unlocked.

In addition, the house has three points of exit, the front, side, and back door. This allows for multiple points of exit in the case of fire or other emergency. In compliance with state code, the home has two smoke and co detectors within 15' of sleeping rooms. Additionally, the solar panels are placed following fire codes requirements of having a three foot clearance along the perimeter for access and fire safety. The siding of the house has class A (ASTM E48) rating for fire safety, which means the material has the lowest fire spread rate and minimal smoke production.

7. LANDSCAPE

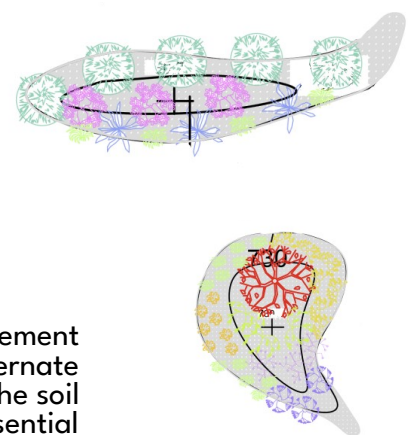
Due to the site's unique grading, the landscape design includes two rain gardens to reduce the amount of water runoff from the site while also supplying water for the rain garden. Native plants are implemented into the design as they will require little maintenance due to their ability to adapt to the local climate and self-sustain. Additionally, the increased plantings on the property will improve air and soil quality around the site and the selected tree varieties will supply natural shading and passive cooling for the house and residents.

The grading of the site and retaining wall protects the home from serious water damage of rain by redirecting water runoff into the rain garden and, therefore, requires less watering by the resident. The selected native plants will require little to no maintenance and not require any type of fertilizer or pesticide. Native plantings are beneficial to the local ecosystem, providing habitats and food sources for native wildlife species. These plants are also perennials and will come back year after year without a need for human intervention.

The built environment consists of a retaining wall, patio, and raised garden beds. Both the patio and retaining wall consist of permeable materials, which reduce the amount of impermeable pavements, such as concrete needed for the site. In addition, the soil underneath the pavers will be able to collect rainwater from the surface runoff.

With the implementation of the raised garden beds, our clients can harvest their own produce, saving both time and money from commuting to a grocery store. The raised garden beds serve also as a feature to provide fresh organic produce, without the need of fertilizers and pesticides. The elevated beds will keep small animals from eating the vegetables and will allow ease of access for the residents to garden. The environmental implications include reduction of nutrient loss from the ground soil and avoid the nutrient-draining impact that some vegetable varieties take on soil.

The soil is not degraded because of the stormwater runoff management system with the rain garden and permeable pavers, ensuring an alternate route for water to take, and avoiding erosion. This also means that the soil retains the proper balance of nutrients and acidity, which are both essential to plant survival. The native plants are resilient to the temperature changes of the region and will adapt to different flows of water throughout the season.





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The planting plan provides many different types of native planting and trees that will create a thriving and scenic environment. The design and materials for the hardscaping and the rain gardens will allow for strong soils and plants as well as prevent degradation and manage stormwater runoff. Rain gardens create their own small ecosystems, and for this property specifically, plants were chosen that will coexist to replenish nutrients that other plants absorb.