U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2020

ADAPTHAUS, TEAM ILLINOIS

Team Contact Information

Faculty Advisor :	Xinlei Wang	xwang2@illinois.edu
Project Manager :	Mayur Mistry	mmistry2@illinois.edu
President :	Jonah Messinger	jonahfm2@illinois.edu
Architecture Lead :	Akshay Srinivas	akshays5@illinois.edu
Operations Manager :	Chris Meilinger	cam11@illinois.edu
Health and Safety Officer :	Luke Lundstrum	lr2@illinois.edu

D6: Project Summary and Public Exhibit Materials

April 21st, 2020

Table of Contents

Project Description

Illinois Solar Decathlon is building a modular house which revolves around the concept of adaptability and affordability. The target market for our project includes young professionals in the Urbana Champaign area. ADAPTHAUS promotes and displays core concepts of sustainability and accessibility through its design features, layout, modularity, and subsystem integration. The design provides users the flexibility to efficiently use the space inside the house for multipurpose activities. For instance, the Airbnb space in Module C can also be utilized as an office space using flexible furniture.

Illinois Solar Decathlon conducted market surveys to understand the needs of young professionals in the Urbana Champaign area. Our design serves the current needs of the client and incorporates provisions for future requirements. We envisioned that a college graduate can initially start with one module when they are single and can expand to two or three modules once they have a family and kids. When their kids leave the house for college, they can reduce their square footage by renting their third module or selling it back to a homebuilder. Thus, ADAPTAHAUS through its multidisciplinary integrated design approach provides a novel solution apt to the needs of the client and embodies a sustainable lifestyle. Our interior design focuses on spatial efficiency by using flexible furniture to have multipurpose rooms. Adaptability and affordability were the core pillars of subsystems design.

Design Philosophy

By keeping flexibility in its heart, the house explores the concept of sustainability in many creative ways. Along with the design of its efficient envelope and building systems, the house optimizes operation, and provides varied opportunities for privacy and communal gathering, lounging and working, and formal and informal activities. ADAPTHAUS is envisioned as a house of the future, one that grows out of the traditional terminologies of the Living room, Bedroom, and Study, and through a structured layout, allows its residents to personalize the house suited to their changing needs, both in space and time.

Presented as an extension of the architectural concept of modularity and adaptability, the landscape design is actively and passively designed to embody the idea of a productive system. The design takes on a curvilinear form that works to compliment the modular nature of the embedded architecture, with planter beds seeded with native plants that would help facilitate the outputs and inputs from the house. The plant selection in particular are drought resistant, with most of them being resistant to urban pollutants too, keeping in mind the high level of salt and pollutants that may pass the site given its location. The carefully selected plant species are complemented with movable modular wooden boxes that can adapt to the users' needs - whether it be a seater by the herb garden, or a storage box that can be moved indoors when necessary.

The structural design philosophy was to keep the design simple but efficient and generic, which would allow the same component designs to be used in all modules. This is essential for efficiency and quality of off-site,

assembly line like construction of the modules. Each module ust also be stiff enough to resist transportation loads without much damage

One of the most prevalent ways to reduce on-site work and to overall follow lean construction standards is to construct buildings using modular construction principles. We optimized our construction schedule and budget as per financial constraints and competition deadlines. We used softwares such Primavera for scheduling purposes, and NavisWorks for clash detections to make sure our modules would be built as good and efficiently as possible.

The reduction in the heating and cooling loads is achieved through a combination of mini-split system with conditioning energy recovery ventilator system CERV2. The primary conditioning will be provided by the ducted mini-split system. A built-in heat pump enables it to heat or cool the air while working in fresh air ventilation or recirculation modes. The supply duct of CERV2 is connected to the return duct of mini-split indoor unit, hence conditioned air is supplied through mini-split into rooms which leads to reduction in loads.

The lighting fixtures and controls were selected with the goal of minimizing electricity consumption and utilization of available daylight. Lighting system comprises of dimmable LEDs distributed around the interior and exterior of the house. Lighting intensity and tone is controlled by the user based on the room usage. The controls of the lighting system utilizes motion sensors to automatically turn off and on the light. All the smart appliances and lighting are connected to the Alexa and can be controlled by voice recommission.

The water infrastructure design saves water throughout the water use cycle, prioritizing water use reduction and optimal usage. The majority of plumbing and water-using fixtures are concentrated in one area of the home, to reduce the length of pipe used and eliminating the need for a hot water circulation pump. Minimal disruption to the existing site encourages natural infiltration. The domestic water design seeks to minimize water usage and reduce grey and black water sent back into the city sanitary system. The appliances chosen for the home also feature low water usage and are WaterSense and EnergyStar where applicable. Overall, the water infrastructure design integrates several approaches to mimic natural site hydrology, improve water use efficiency, and prioritize water conservation.

Energy consciousness remains on the forefront as the design utilizes a solar array with integrated storage measures to ensure reliance to the grid is minimized. The system captures more than enough solar energy during the day to charge the battery and allows users to minimize grid reliance during peak times. The addition of power optimizers on each panel also ensures that we are maximizing power capture. SolarEdge allows the user to set a time-of-use schedule that can pull energy from the battery when electricity costs are high. The inverter can also pull from the grid or the panels depending on the current electricity cost and solar capture at that time. Additionally, due to allowance for the usage of net-metering by local utility, the owner will be able to sell back the extra energy their panels produce during the day and save money on their monthly electricity costs. Finally, as the project will be constructed in a lower income neighborhood, the energy efficient measures and new technologies implemented will serve as an example to the community, showcasing the benefits of integrating a grid-tied solar system and the benefits of such an investment. We intend to spearhead the push towards clean energy alternatives in the Champaign-Urbana area though our project.

Unique House Features

The house is laid out as a two-module unit with front and back patios. The first module is a studio unit comprising a Lounge, Kitchen, Toilet, and Utility. The Lounge doubles up as a Living and Bedroom having a convertible sofa-bed with built-in storage, a foldable coffee table, and sound-proof curtains. The Kitchen Island, with an extendable counter, doubles up as a Study/Workspace. The walls of the Lounge, Utility, and Toilet are adorned with pegboards that provide flexible storage. The second module, consisting of three rooms, is a flexible work/lounge unit that allows its divisions to be used in three distinct iterations, just by making minor modifications to its furniture. In the first case, the entire module serves as an Office- with a Conference Room, a Manager's Cabin and a 2-person Workstation. In the second scenario, the Conference Room dually functions as a Dining Room and an Entertainment Room, the Cabin as a Study/Personal Workspace and the Workstation converts to a Bedroom! The third scenario, perhaps the most compelling one, is where the Bedroom, a lockable space with three beds and built-in storage, is used as an Airbnb. Based on the concept of communal living, this assists the young-professional couple in generating passive income. In this case, the other spaces are communally shared between the residents and the guests- the Study doubles up as a Library/ Reading Lounge, and the Dining Room becomes the central hub for the guests and residents to co-use and bond with each other.

The facade, patio decking, and canopy bring the flexible elements of the house interior to its exterior. The facade, a combination of light and dark-brown vertical wood-veneer panels, uses a standard clip-and-rail system to attach as a rainscreen to the wall envelope. This standard detail provides the flexibility in replacing the panels based on time, location, and other aesthetic preferences. The decking and the canopy are installed as modular elements that are independent of the house structure, helping the building enclosure stay independent of the exterior systems.

The landscape design hopes to present the best of native planting in a residential setting. A selection of low-mow seeds are used to maintain a moderate quality of the lawn with minimal maintenance. By doing so, the design shifts the work done on the landscape mainly on the planter beds that act as rain gardens, or a soft decorative panel that gracefully juxtaposes the wooden facade of the modules - effectively presenting and revealing the processes of sustainability.

The unique structural features include the hybrid use of hot rolled steel as the rim joist of the floor while also using cold formed steel as the floor joist. This is to keep the stiffness of the floor during transportation while still staying economical without having to use the entire floor as hot rolled steel. The connection between the cold formed jamb studs requires a blind anchor fastener onto the hot rolled steel via use of lindapter bolts.

One unique feature of the plumbing design is the tankless water heater. Conventional homes use a water heater tank that continuously heats the water, even when hot water is not being used. This is a waste of energy, water, and space. The tankless water heater takes up less space, and only uses energy when hot water is being used somewhere in the home. The model selected also has self-modulating flow, which further

reduces energy consumption. Additionally, some unique features of the plumbing design include optimization of the plumbing layout, and prioritization of ease of construction/transition. Finally, a unique feature of the home is the stormwater design. Unlike conventional homes, where stormwater is directed into the storm drain system, the stormwater hitting ADAPTHAUS is encouraged to infiltrate directly onsite, where it can help to recharge the groundwater and support onsite vegetation. This also alleviates pressure on the storm drain system during heavy precipitation events.

ADAPTHAUS utilizes a grid-tied solar array that allows the homeowner to generate their own energy and reduce their monthly utility costs. By making use of smart technology integrated into the SolarEdge inverter, the user is able to utilize time-of-use arbitrage and pull from the battery storage system when grid-sourced electricity is at a premium. Additionally, with the design of the current system, there is enough excess energy production to allow for up to three days of continuous grid-islanding capability. In the event of a long term power outage, the homeowner no longer has to fear not having electricity. The resiliency of the design and its ability to adapt to any situation that could occur ensures that no matter what happens, the homeowner can always be prepared. Additionally, with the implementation of power optimizers onto each solar panel the user is able to mitigate the risk of the entire solar array going down. While increasing power production, they also allow the panels to work independently of each other. If one panel malfunctions, the rest of the array will continue to produce electricity. The roof of each module contains a string of 12 panels in series with 12 additional panels being located on opaque areas of the canopy. These opaque canopy areas serve multiple purposes including blocking excess sunlight in the summer, allowing more sunlight in the winter for heating, and providing more roof space without the added footprint.

ADAPTHAUS will have a mobile app integrated with building systems. The infrastructure use is Alexa, we will be using its UI to configure all of our appliances as well as control them. There will be little to no changes to the preexisting UI that the Amazon Alexa App is able to provide, we will however be adding “skills” in order to have the additional functionality that Alexa does not already have integrated with it. Part of this functionality includes energy consumption tips which will let the user know areas of improvement in their consumption, this will be achieved through the combination of our energy tracking monitor and smart plugs to see what good practices the user already has and which ones can be improved upon. Additionally, in order to make this readable and understandable to the user we will be using analogies so that the suggestions are more than just numbers. Finally, the second important aspect that we will provide the user with is a graphical display of their energy consumption, the idea is to allow them to see how they are improving from week to week by allowing them to visually understand their consumption thus far. The rest of the functionality of the App is very basic in terms of controlling appliances via the app and over voice control - both are things that already come with Alexa and we just need to configure to our needs.

Innovations

The proposed design introduces a fresh take on residential landscapes in the Midwestern context, and hopes to set an example for a productive landscape to surrounding communities. The design actively promotes the use of rain gardens and native plants to benefit the surrounding biologies, and rethinks the role of water for the external landscape. By extending the modular design from the architecture, the movable wooden boxes encourage designers and residents to reconsider the flexibility and use of semi-outdoor spaces, and suggest the opportunity to design your private space with ease.

The structural system is composed of cold formed steel as the primary framing material for use in the modular and residential industry, which has rarely been done. The construction method is also through pre-fabrication for the purposes of high-quality furnished homes to be delivered on site, maximizing speed and decreasing costs.

The plumbing design was optimized by considering the needs of both the factory plumber and the onsite plumber, in order to minimize overall length of pipe, ease of transition, and ease of construction. This design could easily be adapted to similar modular homes that are partially prefabricated in a factory and then installed on site. Additionally, our design routes stormwater through perforated pipes directly on site. This then reduces the pressure on the city's storm drain system during extreme precipitation events and improves infiltration on site. Since the site's soils are classified as poorly drained, the perforated pipe will be surrounded by unused construction materials, thus reducing construction waste and surrounding the pipe with a porous medium to allow time for infiltration.

The PV system is designed with a dual focus on functionality and efficiency. The array utilizes 36 Panasonic HIT panels and a SolarEdge StorEdge inverter operating at an efficiency of 99.2%. SolarEdge power optimizers are incorporated onto every panel and serve as Multiple Power Point Trackers (MPPT) to ensure maximum power generation at all times. It also allows the panels to function as separate entities and reduce losses. If something happens to one panel, the issue will not affect the entire array. In addition to using power optimizers in conjunction with an efficient inverter and solar panels, the LG Chem RESU10H battery is integrated into the system to supply some of the house's loads between sundown and sunrise. It also helps the owner avoid relying on grid-purchased energy during peak demand -- usually between 6:00 PM and 9:00 PM -- when prices are high. The LG Chem RESU10H also uses a charge controller to ensure the battery isn't over or undercharged. This makes sure that the lifetime of the battery will be maximized.

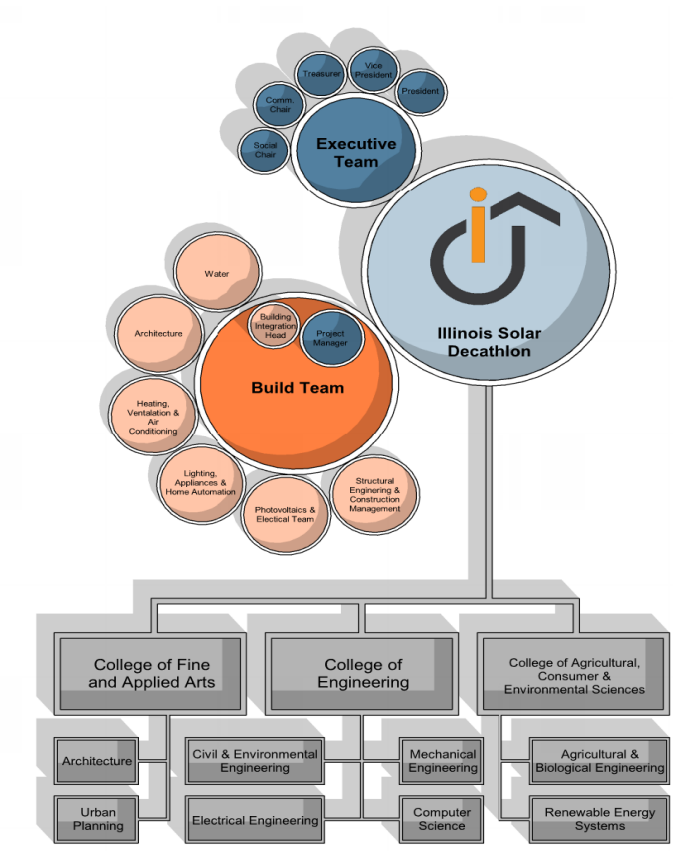
Target Client and Needs

The University of Illinois Solar Decathlon ADAPTHAUS team is building a prefabricated house that focuses on adapting to changing lifestyles. Home ownership is unattainable to most young professionals.Currently, one of the greatest issues regarding housing is the barrier of entry. ADAPTHAUS, staying true to its name, solves this problem through dynamic and flexible solutions for its clientele. The purchase of an inexpensive

ADAPTHAUS in the beginning stages of one's adult life allows for the expansion of the home in accordance with demand for space. Additional modules can be purchased with the introduction of a nuclear family; the same units can be offloaded or repurposed with shifts in demand for space. This allows for the maintenance of a single home throughout one's life.The house is designed to accommodate the ever-changing natures of living, playing, and working spaces. An increased need for virtual communication, divisible workspaces, and convertible functions, is prominently considered while planning the house. Simultaneously, opportunities are provided for the spaces to be used for variable functions during different times of the day, optimizing the energy and operating costs.

Team Organization and College

The project team is student led and comprises graduate and undergraduate students with faculty members and industry partners serving as advisors. The student members of the competition team are organized into sub-groups lead by project manager, sub-team leaders, and sub-team members. Refer to the chart below for a graphical overview of the team structure.



The team is led by the Project Manager, Mayur Mistry, who ensures that the necessary resources are available for the team to run smoothly. The Project Manager manages the budget, organizes meetings, finalizes reports and facilitates the communication both within the team and the external stakeholders. Stakeholders consist of non-student entities such as faculty advisors, industry advisors, the Solar Decathlon Committee, etc. The faculty advisors from the University of Illinois serve to advise students, provide administrative support, conduct relevant classes, provide a bridge of current research to home applications, and support fundraising activities.

The core of the project team is divided into multiple sub-teams. This allows for different components of the project to be handled by a specialized group of team members, which promotes efficient completion of deliverables. Sub-team leads coordinate work among their sub-team and ensure the production of high quality material. They participate in major project decisions and meet weekly with the project manager to discuss progress of the project and any potential changes. These sub-team leaders are students with well-developed experience and knowledge in the sub-team focus area.

Future Plans

One of the key objectives of this project is to foster the development of the local community. Our house is currently owned by not-for-profit organization Solhomes Inc.. We intend to donate the house to Habitat for Humanity post competition which would ensure long-term use for a good cause and contribution to the community.

Community Exhibition

Illinois Solar Decathlon (ISD) will finalize dates for the community exhibition post completiton of modules in Skender's factory. It will be organized on our site at 1402 N. Walnut Street, Champaign, IL. Meanwhile, ISD will continue its outreach and public education in the local community and students virtually. We will be inviting local AIA, ASHRAE, NAHB chapters and ISD Alumni to showcase our house during the community exhibit. Our demonstration will feature tours of our self-sustaining unit, in-depth explanation of design and build considerations in the respective areas of our project. Illinois Solar Decathlon is committed to educating the public and students on sustainable development and green building through our project, ADAPTHAUS. The Illinois Solar Decathlon (ISD) team has maintained a strong media presence and will continue to bolster media involvement. ISD has an active instagram account (@illinoissolardecathlon), facebook page (@illinoissolardecathlon2018) and Linked group as well. We recently published interviews of Solar Decathlon experience of Team Leads on Instagram. We have rebooted our website, which features information about our current and past projects, summary of our team and its leadership team social media and images. During the construction stage, we will be employing an out-of-house videographer to assist our organization in developing an informative and promotional video on our project and team for Solar Decathlon 2020. We will use this video during the competition, at promotional events, and link to it on our new website.