



## Architectural Narrative

### 1. Introduction

Y-House's architectural intent was one of facilitating and encouraging sustainable life choices. Our team felt that sustainable design is interpreted in a way which fetishizes technology. The task the team set before itself was to create an honest, approachable building where people would *want* to spend their time. While aspiring for global change and a reorganization of the conventional politics of built space often goes hand in hand with the tone set for sustainable design, it is equally important to contextualize Y-House within what it can accomplish during the competition and beyond. Thus, the standards of design Y-House was held to only require that it should respond adequately and make use of the local climate, and that it should be a space which evokes a desire in people to occupy it. This philosophy was carefully adhered to throughout the whole design process.

### 2. Modular Approach

From the outset it became clear that to build a sustainable building was not as desirable as to conduct a sustainable project. The building's performance on site is only part of its narrative. The decision to manage a



small, efficient team made conducting a design-build project unfeasible. Furthermore the prospect of shipping a module across a continent would risk debasing the meaning of the word sustainable with regards to this project. Y-House then will be built at a modular facility in Portland, Oregon –much closer to site. This not only reduces the carbon cost of transporting the home but will reduce its environmental impact. The economics of modular construction where the efficient use of the construction process becomes tantamount to financial success means that the industry is better geared towards a more environmentally sustainable mindset. With the addition of a builder willing to eschew conventional practice for better building science –Portland-based MODS PDX— the project could have a much greater disposition to be more conscious from an urban-ecology standpoint. Furthermore, a home with standardized dimensions and construction methods could be replicated much easier than a design-build, greatly increasing its potential for impact.

### **3. The Deck**

In a society where air-handling has become normalized practice, being indoors –by its very definition— is unsustainable. In addition, the climate of the competition site in Irvine, California is famous for its mild character. As a result, a shaded patio will provide equal levels of comfort –and better



levels of air quality—than most conditioned spaces during most of times of the year. Furthermore, the historical tradition of patios as social spaces bonded perfectly with the message of community-oriented sustainability Y-House wants to promote. A patio will not only encourage occupants to spend time outdoors, but invite guests to come in to the house. This sense of welcoming is heightened by the frontal ramp which –at thirteen feet wide—is direct and inviting. The ramp becomes a threshold not only between indoor and outdoor, public and private, but individual and community. The large patio in Y-House is twenty-two feet wide and runs the entire length of the house. It is shaded by a slatted-timber structure which also serves to protect the building from solar insolation. Atop the structure the solar panels provide shading from the harshest sun, but also establish a visual connection with sustainability, as people can gaze into the source of their energy. While being visually appealing the placement of the panels atop the open air patio structure provides maximum airflow helping the photovoltaics stay as cool and efficient as possible.

#### **4. Both/and boundaries**

By placing the patio next to the kitchen and living room area, there is a strong potential to create a social hub of the house. To establish that and ensure it becomes a place both occupants and guests want to be in, Y-



House has a nine foot, folding glass door placed along the length of the dining and living room area. The elongated entry establishes and maintains a strong visual connection between the indoor and outdoor spaces, which is heightened by features such as the continuous bench which starts in the kitchen and eventually wraps around the patio's entire perimeter. The folding partition ensures the threshold between the traditional home space and the patio are blurred. Our entry establishes a both/and boundary where the spaces can be united when desired and closed off when the weather is not inclement. This type of flexibility is necessary when a smaller, more sustainable home must fulfill the programmatic requirements people have grown accustomed to with larger, less sustainable houses.

## **5. The Core**

Because not all of the needs of a house can be fulfilled by situating it within a favorable climate, Y-House had to overcome the challenge of how to adequately provide for the needs of its occupants without compromising its performance oriented design. In order to simplify construction and operations in Y-House's two modular longitudinal modules all services—water, electric, and mechanical—are located only on one of these. Furthermore all the necessary equipment to deliver such services has been placed within Y-House's mechanical core. This 8'x9'x9' core is



manufactured in a distinct location from the rest of the house, immediately challenging notions that all parts of the home must be specifically designed singularly and specifically for it. In fact, this mechanical core was designed with the mentality that it could be employed in all types of constructions from an energy efficient house in Irvine, California, to cold weather applications. Our mechanical module need not dictate a specific configuration of a building. Most mechanical modules include walls allotted to have specific end use appliances, like toilets, sinks, stoves, and fridges plug directly into it. While this certainly makes the construction of one specific construction less complex, it severely limits the application of such a mechanical core. Thus the core of Y-House includes only the equipment necessary for the operation of any building –energy recovery ventilator, heat-pump hot water system, mini-split, inductor, meters, and electrical switchboards. By building two units separately, building and mechanical core, the strategy enables the possibility that, if necessary, the service core can be serviced, upgraded, and even replaced while maintaining the main structure intact.



## 6. Conclusion

Overall, the design of the Y-House is one that seeks to integrate to the networks beyond where its design interventions end. By taking steps to ensure the house design promotes a greater mixed interior-exterior lifestyle and increasing its public role, it is the hope that it will encourage its occupants to be more conscious of a sustainable lifestyle. The Yale team is proud to present its design for the 2015 Solar Decathlon.



## Communications Narrative

### 1. Introduction

Y-House is Yale's first-ever entry into the US Department of Energy's Solar Decathlon. This amounted not only to the creation of a new communications strategy, but brand identity, and support network. Because this was conceived and carried out entirely as a student-led project with little backing from Yale College or the Yale Corporation, this meant the communications strategy was tantamount to the team's success with direct carryover into its fundraising efforts. As such the strategy was focused around creating the identity of a team of students undertaking a build-project for the first time with high tech/performance components. Our goal was to inspire the message that sustainable living can and should be approachable from the standpoint of all homeowners.

### 2. Goals

**Update:** Keep our audience engaged through documentation of the design process

**Brand:** Create the narrative of the Y-House as approachable

**Connect:** Yale has a large network of alumni who love their school and remember it as a student-centered institution. Y-House should capitalize on



that by engaging directly with them either through student-contact, industry-help, or in person meet-ups at branches of the Yale Clubs.

### **3. Strategies**

#### **3 i. Presence**

A successful communications strategy is always hinged on some form of presence. Communications technologies and online platforms have facilitated maintain a presence, however, it was the strategy of the Yale Team to prioritize in-person presence. This was done through in-person meet ups at conferences like the Yale Energy Conference, the Yale Alumni in Energy Conference, attendance at various trade shows like ICFF, presentations at various Yale Clubs across the nation, and local networking with New Haven artisans. This was supplemented by a large online presence in traditional social platforms like Facebook and Twitter. Even so a large portion of our interested target audience, Yale Alumni, remained untapped. To reach out to them we contacted a many Yale Alumni through the phone to leverage fundraising or contacts. Lastly we maintained a constant Yale-centered presence by collaborating with a large number of Yale organisms like Yale West Campus, Yale Center for Business and the Environment, Yale Climate and Energy Institute, and Yale School of



Architecture which were eager to advertise their involvement with a student group.

### **3 ii. Content**

The content materials for the promotion of the Y-House centered on creating the image of sustainability as a community-based undertaking. As such the creation of legible, appealing, and playful documents became a priority. The goal of all content of Y-House was to personalize our image as a team, constantly updating our followers on our doings to send the message that sustainability is an individual's choice that can be approached by all kinds of people.

## **4. Audience**

The message the Yale Team is bring to California is one of community-based approach to sustainability. As such all of our messages were tailored for the creation and inclusion of a community. First and foremost this meant our peers and professors. The school should be proud of its participation in such a prestigious event and our materials hoped to inspire that sense.

Next it meant the inclusion of the greater Yale community. Because Yale is a liberal arts institution that prides itself on critical thinking our message had to involve an audience by highlighting the holistic approach we were taking by inclusion of several Yale organizations, further use of Yale resources



(like wood from its forests), and collaboration with alumni (like Vermont-based architect Eli Gould, Ambassador Richard Swett, and Yale Club presidents across the nation)

## **5. Themes**

### **5 i. Approachable Sustainability**

- Sustainability cannot exclusively be the realm of complex technologies and exotic designs. True sustainable design must be approachable.
- Approachable sustainability starts with the creation of spaces that people want to inhabit and socialize in.

### **5 ii. Community-Based Sustainability**

- Environmentally friendly construction is not a singular phenomenon, but must be a community-based movement.
- Community-based sustainable movement starts at the building stage, with modular construction that can be replicated and used to build actual, physical communities.
- A community-based approach must be one that builds a social community. Thus the integration and blurring of public/private lines must be made so that the message of sustainability attracts others, builds social networks, and is given a platform on which to spread.



### **5 iii. The Mechanical Core**

- “The heart and brain of Y-House”
- A modular based approach that can easily be replicated and added to a whole variety of building designs quickly.

### **5 iv. The Yale Community**

- Promotion of Y-House’s efforts by various campus entities.
- Integration of multiple institutes and Yale organizations (YCEI, YEI, CEID, CBEY, YSOA, Yale West Campus)
- Collaboration with student projects like the vibrant restaurant pop-up culture, and the SOM-based student furniture start-up Hugo + Hoby.

### **5 v. Homegrown Industries**

- From its defense-industry related origins and potential end uses the mechanical core is equipped only with American, Danish, and German components.
- Prioritization of equipment was given to local manufacturers and suppliers that were creating product with distinct features and of equal/better quality than established industry leaders.



## 6. Performance Evaluation

Because the students behind the concept and execution of Y-House were responsible for funding the project the metric for our performance is a simple one. The performance of the communications strategy of Y-House is directly reflected in the funding efforts of the house. A well-planned, stimulating, involving campaign will compel the Yale community to step up and fund the house where their university failed to do so. Of course this is contingent on all of the steps outlined above as well as others like media presence (articles about Y-House can be found in Yale News, the Yale Daily News, the New Journal, the New Haven Independent, and YTV), social-media standing, and the maintenance of a successful alumni connections effort.



## Engineering Narrative

### 1. Introduction

Whereas many competitors see the Solar Decathlon primarily as an engineering challenge, Team Yale instead saw an opportunity to emphasize its strengths and design for engineering and architecture equally. Our belief is that good architecture design should need little additional engineering to accomplish the goals of human comfort. To that end, we have intentionally designed our engineering to be minimal and elegant, in many instances combining multiple systems to improve efficiency and minimize our footprint. The following narrative follows the design process of our small but dedicated engineering team, working in conjunction with a panel of industry experts. All mechanical and electrical calculations were made by undergraduates and stamped by professionals as appropriate. We are happy to present a vision which has remained constant throughout our two-year process, and we believe has substantial value as a scalable concept.

### 2. The Mechanical Module

#### 2 i. The Heart of the House

Our central engineering concept started with the idea of a “wet wall.” We knew that for such a small footprint, the most economical way to organize our engineering would be to locate all of our plumbing appliances in the same place.



These appliances would be serviced by our hot water tank located in our mechanical core. However, our team quickly realized that our mechanical core could be so much more than just a part of our wet wall. We began to see our core as the heart of the house; in the same way that all veins run from the heart to service the extremities of our body, so too does all plumbing, wiring, and ductwork originate from our mechanical module.

We then took our mechanical core concept one step further. Technology is constantly changing, and we wanted to design a module which could easily be replaced and upgraded. Using the heart analogy from earlier, we wanted to create a universal transplant which could be continuously and conveniently improved upon. Our module comes with pre-constructed connections, allowing it to easily integrate into the pre-existing plumbing, ducting, and conduit runs of our home. With the help of Ironwood Brand, a Vermont-based prefabrication company owned by a Yale alumnus, and F+F Mechanical, an engineering firm in New Haven owned by Yale alumni, we were able to realize a module which accomplished all of our goals. The mechanical module included in our submission is a template for an idea with almost limitless degrees of reconfiguration and scalability.



## 2 ii. Selecting Core Systems

Besides the innovation of our mechanical module construction, we also paid very close attention to the systems being installed in our house. Our goal was to combine systems in unconventional ways, to reduce our footprint and increase efficiency. To that end, our sponsors were helpful in suggesting novel ways that their products have been used on the market. These suggestions have been implemented in our mechanical module, and we hope that visitors to the Y-House will learn new retrofits that they could install in their homes.

- Plumbing – The core of our plumbing system is an Accelera 300e Hot Water Heat Pump from Steibel Eltron. The Y-House is the first construction in America to install this technology, an upgrade from previous 200e and 300 units. The Accelera 300e is equipped with an air-to-water heat exchanger, allowing the hot water tank to increase water temperature using pre-existing heat in the ambient air. This heat exchanger has been shown to satisfy nearly 90% of a home's hot water consumption without consuming electricity, although the Accelera 300e is additionally equipped with a back-up electric boost heater. Superior programming ensures maximum energy savings, and superior insulation ensures minimum heat leakage. Our plumbing runs are constructed from PEX tubing for ease of connection and construction.



- Energy Recovery Ventilator – Our primary mode of conditioning is a CERV unit from Build Equinox. While we have designed our home to rely primarily upon natural ventilation to condition our house, the CERV helps us to maintain code requirements for minimal energy cost. The CERV includes an on-demand ventilation option, as well as limited heating and cooling capacity which can be used to desiccate and provide additional conditioning. Flex ducting runs located in our drop ceiling allow the CERV to cycle air between rooms, removing operational loads from places like the kitchen and transferring them to the bedroom and study. The CERV is also ducted through our Accelera 300e unit, allowing us to heat our hot water from the heating load of the house.
- HVAC – In addition to the CERV, we have also installed a 1.5 ton ducted heat pump from Carrier in the drop ceiling above our central hallway. We originally conceived of this unit being inside our mechanical module, but realized that placing it over the hallway would considerably reduce our amount of needed ductwork. While our ClimateConsultant data simulation claims that the combination of natural ventilation and the CERV will maintain the required 71-76°F temperature range for 8700 hours out of 8760, we want our home to be comfortable 100% of the time throughout the year. When natural ventilation is not an option, our heat pump allows us to seal our house and maintain a comfortable temperature.



- Appliances – In general, we have installed the most energy-efficient appliances on the market. Of particular note is our 12 cu.ft. freezer/fridge from SunFrost, which consumes only 0.29 kWh per day. In addition, we have located our washer and dryer in our mechanical room for aesthetic and noise concerns. Our heat pump dryer from Whirlpool consumes 73% less electrical energy than a standard electrical dryer. Its remaining operational load contributes to heating our Accelera 300e unit.
- Power Distribution – To ensure that our mechanical module can easily be replaced, we have installed a 100A load center in the module itself. This load center contains the breakers for the CERV, the Accelera 300e, our washer and our dryer. This load center is located directly opposite our main service panel, and the two are easily connected by conduit running through the drop ceiling and the wall. Our appliance load for the house is so low that we can connect our photovoltaic inverter load-side to our 200A main service panel without requiring an additional outsize bus. For safety reasons, our inverter and AC disconnect are not part of our mechanical module and are located instead on the wall behind our bathroom.
- Insulation – Mechanical rooms can get noisy. Given our small footprint, we did not want our mechanical module to detract from the living experience of our residences. In addition to regular insulation, we have installed a layer of cork from Amorim to insulate this operational noise. It is a natural



material that does not off-gas chemicals and insulates the main module from heat given off during the operation of the equipment.

- Controls and Monitoring – We believe that for a house to be truly intuitive, our resident needs to be able to see the effects of their energy decisions. Our SolarEdge 10000A inverter, SolarLog 360 meter, and CERV all come with wireless monitoring features that allow residents to track their energy production and consumption.

### **3. Engineering the Y-House**

#### **3 iii. Modular Construction is the Future**

While our mechanical module was constructed on the East Coast by Ironwood Brand to control quality, the rest of our home was constructed by MODS Modular Construction in Portland, Oregon. Being an East Coast team, Team Yale wanted to avoid the pollution and energy consumption associated with shipping our net-zero house across the country. Hiring MODS allowed us to make use of material and labor local to the West Coast, and also to make sure that our construction and sealing were of professional quality. Modular construction is a rising trend which Team Yale wanted to take advantage of and support.



For engineering, MODS was responsible for installing our plumbing and conduit runs to our specifications, as well as our mechanical systems not already included in our mechanical module. Since Yale does not have a structural/civil engineering department, MODS also helped us with our structural calculations. Through MODS, we were able to realize our vision in a considerably shorter time frame and with considerably less waste than if our team were to construct the house ourselves. MODS is familiar with custom design projects, and worked with our other sponsors to ensure minimum discrepancies between the final product and our house as drawn.

### **3 iv. The Path to Net Zero**

Our mechanical module strategy explains how we have reduced our energy consumption as much as possible while still meeting all Solar Decathlon competition criteria. Our Accelera 300e unit lets us take the operational loads from the house and convert them into usable hot water without consuming electricity. Our CERV unit lets us transfer operational heat around our house. Our appliances, including our e-Golf from Volkswagen, are among the most efficient on the market. Superior windows from Alpen and insulation from 475 High Performance Building Supply ensure that our house is well insulated, while the shotgun configuration of our house allows us to quickly flush out any unwanted heat. With the Y-House, we believe we have accomplished our goal of optimizing natural ventilation and minimizing our engineering systems.



The other side of net-zero is photovoltaic production. Our team started by calculating a worst case scenario, finding out how many panels we would need to ensure our house would remain net-zero in all circumstances.

Simultaneously, we had to balance this number with the physical number of panels possible to fit on our roof. We settled on a compromise: a 32-panel, 10 kW array which fits entirely on our trellis.

Our photovoltaic panels are 320W, 60-cell modules sourced from Cogenra. Their unique Dense Cell Interconnect technology ensures maximum power output by substantially reducing losses from shading. Their 320W panels are so efficient that they actually exceed the voltage rating for SolarEdge's P320 DC optimizers, requiring us to upgrade to a P400 model usually reserved for 72-cell modules. These DC optimizers allow us to monitor each panel remotely, and also help prevent one faulty panel from influencing an entire string. By mounting our photovoltaic modules over our trellis, we expose our modules to free air flow which helps to reduce operational load. Our modules are installed at a 5 degree tilt, allowing us to fit the maximum number of modules on our roof while at the same time avoiding dust collection and other hazards. The result of these strategies is that we are producing the most power possible for a house of our size and should have substantial excess.



#### **4. Conclusion**

After the competition, the Y-House will relocate to an art installation founded by Yale alumni outside of Charlotte, NC. There it will continue to operate as a residence and showpiece, allowing us to continue monitoring our house's performance throughout all environmental conditions. With this extended monitoring we will be able to show the market potential of our mechanical module system, and also continue to educate visitors about the advantages employed by the Y-House.



## Market Appeal Narrative

### 1. Introduction

The market for the design of Y-House is for young professionals. Given that the Millennial Generation is coming of age and looking to settle down, and that they have been raised against a backdrop narrative of environmental toil and strain they are the most likely to adapt their habits to live sustainably, Y-House can achieve maximum impact by catering to them. Other themes like the rejection of single-family standalone housing by millennials so far and desire for community interactions beyond the digital realm position Y-House within their target market.

### 2. The Mechanical Core

While the idea of centralizing all building services is not a new concept, its current implementation greatly increases the appeal and marketability of the Y-House. However, a centralized service room should grant greater flexibility when designing a home or for other end uses, not burden designers with another set of constraints. By leaving out end-use appliances that would actually affect the layout of the house and limit the uses of the core, it only contains within it all of the equipment necessary for the operations of the house. In the 8'x9'x9' module all of the mechanical and electrical equipment is



contained. Thick, natural cork insulation ensures that their operation does not perturb homeowners with their noise and isolates the house from any heat gain operating these systems may cause. Furthermore the core uses entirely commercial-grade elements and can be mass produced in a modular factory. The use of standard interconnections ensures it can be applied to a variety of situations, maximizing its potential impact.

### **3. Target Client**

The target client of the Y-House is a single person or couple who are interested in living sustainably. The relatively low cost of the construction of the house places it within reach of many young professionals looking to settle into a more permanent home. Furthermore its modular construction enables it to be installed in a variety of places and not be limited by a single region. Features like slide off sheathing allow for insulation and house wrapping upgrades to be easily applied effectively making Y-House marketable to a wide range of climate zones across the country.

### **4. Yale Real Estate Association and the Landbank Foundation**

Throughout the past months the Y-House team has been closely collaborating with a member of the Yale Alumni in Real Estate Association and another Yale Alumni in finding a permanent resting place for Y-House. The result of their



efforts along with a U Penn graduate is the Landbank Foundation. The foundation, with a large parcel of land in Randolph County North Carolina, will focused on creating an artist's community for collaborative learning in a unique place enriched by site-specific art installations. The Landbank Foundation has at its core a message of returning to the land and conviviality with nature –ideals which match closely with Y-House's message of a community-based approach to sustainability. Collaboration with the foundation has allowed the members of the Y-House to reach out to a new demographic of Yale alumni interested not only in the environment and sustainability but in art patronage as well. Given that it is in Randolph County, some climate specific upgrades will need to be applied to the envelope of Y-House but its climate is also mild avoiding the harsh temperatures and high humidity of the East Coast.

## **5. Affordability**

Based on close work with our building partner MODS PDX the Yale team is confident in the affordability of Y-House. Construction of the module is valued at \$155,000 and with on-site construction its value still sits below the \$250,000 threshold. Even considering a parcel of land which traditionally accounts for 30% of a home's value the total cost comes in at \$400,000. While some may see this as a high price to pay for a small home, its technologically advanced features (particularly its large solar array) add substantial cost that



a regular home would not incur, but pay off throughout its lifetime. Features like the CERV which monitor for air quality ensure that savings will not only be passed onto the consumer in the form of reduced utility bills, but in health benefits by providing a clean environment to combat adverse health effects like sick building syndrome.

## **6. Technology**

Y-House operated under the mantra that there should only be as much technology as necessary for the operation of the house. Often times systems are oversized for peak loads which rarely occur resulting in the installation of equipment that consumes much more energy. Y-House solves these problems by having a staged approach to the problem. The conditioning energy recovery ventilator will provide adequate means to condition the space most of the time. Furthermore even the most efficient equipment can never be as efficient as the use of no equipment. By utilizing sensors to monitor for temperature, humidity, air flow, and air quality the system can be programmed to know when to shut off when it is not needed. When this equipment is not necessary works to transfer its excess heat to heat water while cooling the air. In the rare occasions this is not enough, a mini-split system boosts the cooling capacity to provide a comfortable environment in an energy efficient manner. Y-House also features other high-technology pieces of equipment like LED lights which last longer and



are more efficient than conventional lighting technology. Of course, the marquee feature of Y-House, its 10.5 KW solar array is displayed proudly above the patio, which also provides optimal air-flow and cooling capacity for their operation.

However, a large part of the technological advancements of Y-House come in recognizing that technology is always evolving and providing the adequate path to allow for its continued improvement. Architectural features like the drop-ceiling allow components to be easily swapped out, upgraded, and reconfigured without perturbing the building envelope, which carries some of the most technologically advanced materials from a building-sciences perspective. The mechanical core also carries this kit of parts mentality as it can be detached allowing for new equipment to be installed, serviced, or even swapped out should a new design be found more advantageous.

## **7. Air Quality**

The occupant-centered nature of Y-House not only extends to creating an inviting spatial environment but to looking after the health of the occupant. The nature of high performance buildings with low infiltration rates can leave people exposed to the particles and chemicals from materials that may be off gassing. Thus it becomes necessary to monitor the air quality of the house. Our



Conditioning Energy Recovering Ventilator sourced from Build Equinox was originally developed for healthcare applications. So while it is incredibly energy efficient, it has a double function that continuously monitors for a variety of airborne particles. The implementation of the system is programmed so that when operable windows of the home are open and enough fresh air is cycling in, the system automatically shuts off, using no energy and maintaining a healthy environment. When the system is needed it has a filter to reduce particle levels to an acceptable set point.

## **8. Appeal**

The appeal of Y-House centers on a home whose operation does not require the knowledge of a systems engineer nor the programming skills of a software designer. This philosophy does not only stem from a systems perspective, but from an architectural philosophy. It is a simple fact that humans seek to emulate what they find admirable. This is why the team spent so long considering so many designs and countless variations because at the end of the day the only metric that matters is occupant satisfaction. It is often lost on building designers that their buildings serve the people not the systems. Humans are not imperfections of the system, nor should they be required to ascribe to their performance metrics. Thus in creating a pleasurable series of



spaces that also are incredibly energy-efficient Y-House aims to draw its appeal and fashion its impact.