SOLAR
CAL POLY

INhouse

architecture.

INhouse – An Idea

The design of this house is driven by climate and place.

INhouse is intelligently designed to respond to the conditions of the climate in coastal California, such that the majority of its needs for heating, cooling and lighting are addressed architecturally. The supplemental systems necessary for the remaining space conditioning, lighting, and power needs are efficient and effective. The public and private wings are serviced by an active core that contains the home's mechanical, electrical, plumbing, and monitoring systems. The private wing includes a master bedroom and a flexible space which may serve as a library, office, or secondary bedroom space. The public wing incorporates entertainment and dining spaces with thoughtful linkages to the exterior spaces and the views beyond.

INhouse: Intuitive, Interactive, Integrated
INhouse is designed to inspire its residents to take control of their personal environment. Intuitive, interactive, integrated: our interpretation of net-zero, a new way of interpreting a contemporary California home. INhouse explores the link between system and resident, with the goal of making operation and management intuitive, energy affordable, and waste minimal.

Our mission is to create a home that meets both the residents' as well as society's need for ecologically responsive housing while simultaneously creating an environment that delights the resident both experientially and thermally. INhouse has also provided an opportunity for students and faculty to explore, collaborate, and introduce innovative, responsive design through hands-on learning.

From the explicit to the subtle, INhouse is designed to be intuitive, interactive, integrated:

Intuitive

Through a precisely designed envelope and passive systems, INhouse is crafted to maximize the thermal and luminous comfort of its residents. Residents can easily learn how to operate the passive systems of the house - sliding screens, sliding glass walls, operable windows - in order to maintain their daily and seasonal comfort. Through a straightforward control system, residents can optimize their luminous and thermal comfort by communicating on site or remotely with the supplemental systems of the house, which include heating, cooling, and lighting systems. The operation of the INhouse systems does not require any rigorous training; the design of these systems is intended to be intuitive. By actively engaging with INhouse, residents can save energy, reduce costs and maximize comfort. Over time, residents will learn that small changes in their daily habits can result in a reliably comfortable living environment - one that not only elicits sensory delight but also realizes real energy efficiency.

Interactive

INhouse provides an environment that enables the resident to adjust the house to meet changing needs. Interaction with the house is based on the resident's senses and aims at enhancing each experience. When the weather is nice, s/he can open the folding glass wall between the living module and the outdoor solar bifacial room. When the sun is least harsh or views are too good to pass up, the resident can push open sliding screens along the southern edge of the bifacial room. By enjoying the bifacial room itself, the resident is directly interacting with one of the home's methods of energy production. Meanwhile, real-time feedback informs residents about energy use and production, allowing them to appropriately respond to this information. The interactive features of the home allow a fully customizable experience that can be tuned to the needs of the occupants.

Integrated

The home is designed around a core that contains its active intelligence - mechanical, electrical, plumbing, and monitoring systems. INhouse aims to unify all of the home's components into a coherent whole - from passive to active, indoor to outdoor, and architecture to engineering. All systems are integrated, creating an efficient home that is simultaneously delightful as well as user friendly. The resident dwells between the core and the wings, in open and comfortable spaces where thoughtful architectural design and mechanical systems meet.

INhouse

This house is a manifestation of Cal Poly's core directive, "Learn by Doing." By drawing on our school's unique capability as a polytechnic university, our multidisciplinary team accomplished all aspects of designing, engineering, and constructing "in-house."

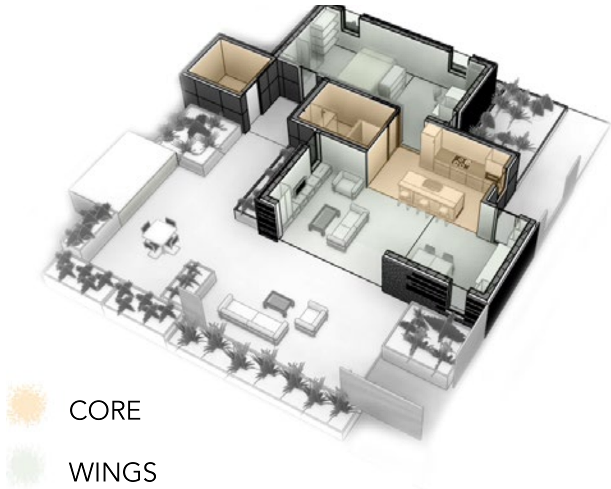
Holistic Design

INhouse represents a collaborative team effort, a cohesion of architecture and engineering in which the sum of the parts result in a larger cohesive and delightful whole. Our design combines materials and systems to create a modern California aesthetic.

Passive | Active

Designing INhouse to minimize environmental impact and maximize climate responsiveness and comfort begins at the most basic level - building shape and placement. The home's spaces are thoughtfully arranged with solar orientation in mind.

In a temperate climate such as San Luis Obispo, with near equilibrium between heating and cooling degree days, the design of INhouse utilizes these elements to achieve comfort balance. The team's climate analysis led to five primary climatic design priorities: organize, insulate, shade, ventilate, stabilize. To organize, the house is elongated on its east-west access and the interior is zoned for maximized comfort. The public day use spaces are on the south, and the private predominantly night use spaces are on the north. To insulate, the 8 1/4" structural insulated panels [SIPs] in the walls and ceiling provide an R value of 30.5. The SIPs combined with the R 24 floor results in excellent insulation values and a tight envelope, an appropriate design approach for our target climate zone. To shade, the house uses multiple strategies, including both the bifacial room on the south as well as the redwood screen on the wings. To ventilate, all the windows are operable, including the north-facing clerestories in the taller core, which are designed to promote stack ventilation. To stabilize, a phase change material duct runs the length of the core, dampening temperature swings on the interior.



Core | Wings

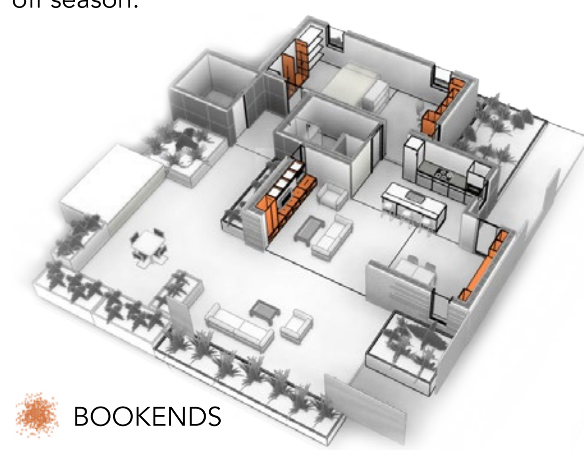
INhouse includes two wings - one public and one private - linked to an active core. On the exterior, the core and the wings are formally and materially differentiated through volume as well as materials. The passive wings are lower, more porous, and are defined by a redwood screen designed to shade the envelope as well as to highlight the origin of our project, the central coast of California. The taller active core is more sleekly designed, using panelized construction, and enclosing the home's comfort systems.

On the interior, the core and wing organization creates a separation of space that allows for an open floor plan for the public spaces, while maintaining the option of privacy. In addition, purpose-specific casework is integrated along the short ends of the wings, creating a "bookend" effect that minimizes clutter and defines space. These bookends are also an example of the project's overall holistic design. The bookends act as thermal buffers through their east/west orientation, acting as additional indicators of the project's climate responsiveness. They also provide spatial organization as well as material and textural interest to their adjacent spaces.

Inside | Outside

Connected by a 15 foot NanaWall®, the public wing seamlessly connects to a generous outdoor area, emphasizing the outdoor living potential afforded by the coastal California climate and doubling the home's public space. The outdoor decks provide residents with additional square footage that is essential for an otherwise modest house footprint. This outdoor space is adaptable through operable shading screens that allows user–defined comfort in response to the changing seasons. In the bifacial room, shading with bifacial PV panels not only offers refuge from the harsh southern sun but also provides additional power for the house. This includes some power gained through reflected light, one of the attributes of bifacial technology.

The constructed wetlands are an additional indicator of holistic design. In drought stricken California, progressive thinking about water use is essential. Greywater from INhouse is captured and channeled into the wetlands, transforming a resource that was once considered waste into a precious resource that provides a touch of natural delight for the inhabitants. Additionally, the other planters located around the walls of the house collect the rainwater from the roof. These small rain gardens are planted with local vegetation which become dormant in the off season.



SOLAR CAL POLY

Layers of Light

Creating a delightful luminous environment is the primary goal of INhouse. Active inhabitants are able to control a system that mediates daylighting and color-consistent LED electric light sources to meet their lighting needs. INhouse manages to achieve quality lighting design while consuming only about .5 watts per square foot of energy.

Layer One: Ambient Light

Daylight is the primary medium for ambient light during the daytime hours. There are ample windows in the southern public wing, providing not only light but also views and ventilation. The core is designed with a north facing clerestory, which serves the dual purpose of providing visually comfortable northern light in the spine of the house as well as necessary stack ventilation for thermal comfort. The private wing has more subdued daylighting, in response to its use: task work and sleeping. To supplement the daylight, the ambient electric lighting throughout INhouse is designed to be reflective, with luminaires directed toward architectural surfaces to provide soft reflective light in all of the spaces. Examples of this effect can be seen through the use of wall washers in the wings, which are aimed at the bookends, as well as the uplighting in the core.

Layer Two: Focal Glow

Focal glow is useful for creating singular luminous moments. INhouse uses focal glow at those points where inhabitants and guests might gather: at the dining table or at the kitchen bar. These effects are realized through the thoughtful placement of dimmable LED pendants: the jewelry of the lighting design.

Layer Three: Task

While ambient light provides illumination for general spatial navigation, task light illuminates specific activities through direct light. Inside INhouse, task light is applied in the kitchen, in the bathroom, and in the private wing. The kitchen uses under counter lighting to illuminate food preparation. In the bathroom, sconces are located at either side of the mirror to avoid shadowing down an occupant's face. The bed is near a reading light and the desk has a task-specific lamp as well.

Luminous Mediation: Controls

INhouse utilizes a relatively simple yet effective lighting control system that allows the inhabitant to interface with their luminous environment in a nuanced way compared to a traditional on/off interface. Inhabitants can control lighting levels through wall controls as well as remote devices, creating personalized scenes according to their needs. In addition, the system supports remote access to the luminous as well as thermal environment through a smartphone application that controls lights and temperature.

SOLAR CAL POLY

Quality Design: Materials, Details, Scale

In order to realize the design intent of INhouse, Solar Cal Poly established a goal of selecting materials of superior performance and quality.

Performance

The team selected materials based on thermal and environmental performance as well as durability. Many of the materials selected for the project come from the West Coast.

Quality

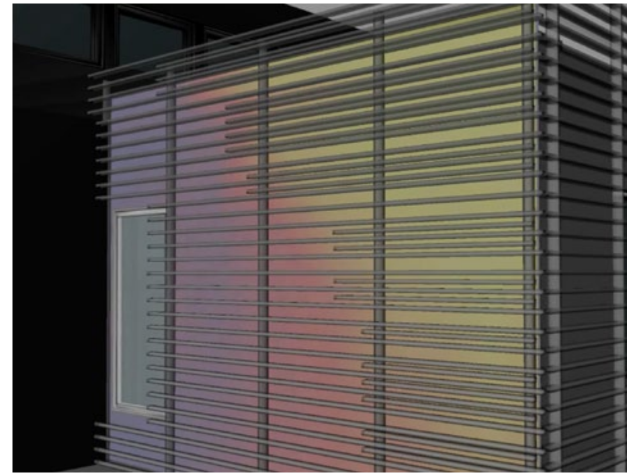
Material performance alone is insufficient for delightful design; quality is essential to achieve delight. For the team, this translated into choosing materials not only for their aesthetic potential but also for their longevity.

With these filters established, the rationale behind the material selections for INhouse becomes clear. The envelope is predominantly constructed of structural insulated panels, which combine structure and insulation into one component, resulting in higher R-values, faster construction times, and a tight envelope.

On the exterior, the core and wings are materially differentiated from one another. The core utilizes a panelized material made with FSC® certified and post consumer waste paper content; it also requires no additional treatment. The wings are predominantly screened with locally sourced FSC® certified redwood. For performance, the redwood screen shades the envelope and is patterned as a solar thermal map of the house, with the denser areas indicating zones of higher solar intensity. For quality, the redwood identifies the project as a product of its region (coastal California) detailed and crafted to create a modern California aesthetic. On the south, the screen continues past the limits of the envelope to shade the exterior, providing privacy and creating a comfortable outdoor room.

On the interior, INhouse's contemporary aesthetic draws on a blend of light colors and wood to create comfortable and delightful spaces. The light walls are intended to work in concert with the architectural lighting to create an expansive feeling in the relatively small spaces. The flooring and bookends are intended as a gentle contrast, using the warmth of FSC® certified bamboo flooring and cabinet faces as a material counterpoint.

Also within INhouse is a material that is mostly hidden: phase change material [PCM]. Following good passive design principles means that INhouse needs thermal mass in order to dampen temperature swings and to better maintain thermal comfort. Most of this material is out of view, located in the phase change duct that runs the length of the core. In order to educate inhabitants, the team chose to display some PCM material through the more interactive art piece along the south wall.



Size Matters

The choice to build INhouse of high quality materials and at a specific size was a conscious and conscientious choice by the team. While building a larger house with better quality materials can result in higher cost, the team felt that these choices add to the longevity of the project. Conscientious selection of superior materials results in a built object that will last. A larger footprint allowed us to design a project with future adaptability in mind, as evidenced by the flexibility in the private wing. In this way, these choices were conscious objectives for INhouse, looking forward to its constructive use beyond the competition period.

INnovation

Differentiating between the active core and the more passive wings exemplifies an aspect of INhouse's design ingenuity. Locating the active systems in a central core allows for more design freedom in the wings and thus presents an opportunity for replication without duplication. If replicated, the number of wings might be different, or in a different configuration. The core itself could be prefabricated and mass-produced. Either of these components could be fabricated for high-end or more modest clientele.

Creative use and expression of material was also a goal for INhouse. The use of PCM as a thermal moderator is one example. The use of the redwood as an expression of thermal shading and solar thermal mapping is another. Each of these represents an emerging chapter in the design professions, as we employ our parametric design tools to help us simultaneously achieve superior performance as well as delightful aesthetics.

Perhaps the Solar Cal Poly team could have designed a house that operates entirely independent of its residents, but a "smart home" is of less value to society than a "smart resident." This holistic approach stems from the shared vision and close collaboration between the many disciplines involved in creating INhouse. Residents of INhouse will be encouraged to learn how to live net-zero, and the house itself will be the vehicle of their education.

The Solar Cal Poly team presents a new standard of "in" by creating a notion of ecological living that is enticing as well as achievable. INhouse is an approach to living well, while still living within our ecological means.

market appeal.

The Golden Coast

For over forty years, California has been at the forefront in mandating the most rigorous energy standards in the country. Recently, additional requirements were passed which require all new residential construction to be net-zero by the year 2020 and all new commercial construction to be net-zero by the year 2030. These regulations are changing the landscape of design in California. To build a home that harmoniously fits into California's future, we focused our design on climate and place.

According to Architecture 2030's report, "The Roadmap to Zero Emissions," approximately 60 percent of the built environment will be built and rebuilt around the world in the next two decades. INhouse sets a precedent for efficient, performance-based design. With the need for net-zero energy homes in California rising, INhouse is an excellent option as it provides a quality, cost conscious home made predominantly of locally sourced materials.

INhouse is designed to integrate into the landscape of coastal California, encompassing a six county region from San Luis Obispo County in Central California to San Diego County in the south. These counties have a Mediterranean climate in which the ocean moderates the temperature year around, producing milder winters and cooler summers.

An important factor in these climate zones is the diurnal temperature variation, the significant difference between the maximum and minimum daily temperatures. As the biggest energy challenge is providing and maintaining thermal comfort, we worked to design a project that works with, and not despite, the climate. We utilize the diurnal variation to passively cool the house at night. Additionally, we utilize other passive design strategies to emphasize the use of building design and material metabolism as the first response to providing thermal comfort.

INhouse creates an intuitive, interactive, and integrated home for an individual or couple who have an eagerness to interface with and adapt to the home. We designed an open public space that connects the kitchen, living room, and dining room to create a large, delightful environment for occupants and visitors alike. Inhabitants can transition between each space as well as double their living space by completely opening the fifteen foot NanaWall® inviting a seamless indoor to outdoor connection. The private wing is separated with a sliding door for privacy. The flow of the home focuses on convenient paths and minimal doors for spatial fluidity.

California Living

In our region of California, the temperate climate allows residents to enjoy the outdoors year around. We focused on creating a connection to the outdoors thus maximizing our living areas. By having more than 700 square feet of outdoor living space, we are encouraging inhabitants to enjoy the backyard as their outdoor living room.

In the landscape design, INhouse employs water-saving features to reduce the use of fresh water. As of June 2015, our target region is labeled as being in Extreme Drought on the Palmer Z-Index according to the National Centers for Environmental Information. We designed INhouse to use as little water as possible. Our roof redirects storm water directly to our planters, which are designed as rain gardens. These gardens naturally filter the water through the landscaping and soil. Each planter acts as a sponge, allowing storm water to slowly percolate into the ground rather than quickly running into a storm sewer. The rain gardens utilize local plant species which are drought tolerant and fit into the existing California landscape.

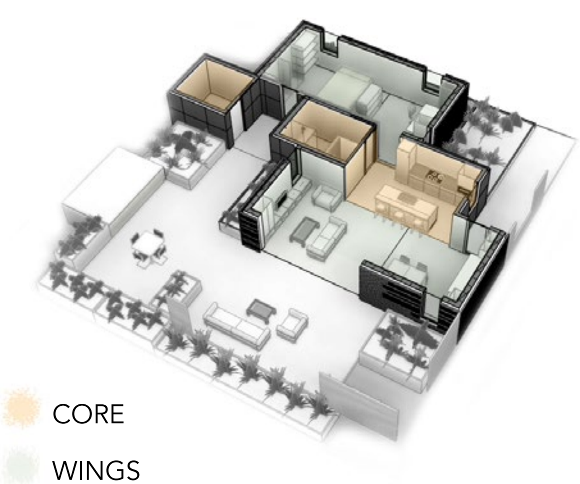
Another water-conscious feature at INhouse is the constructed wetlands system. This system cleans and recycles all of the gray-water that the house produces and directs it to be used for landscape irrigation. The planters in the system have three layers of soil topped by native plants. As the water steps down each planter, it waters the plants on the surface and the remaining water is filtered through the gravel and sand. After running through the constructed wetlands planters, water continues to the remainder of the planters on the south. Not a single drop of freshwater goes towards the irrigation of the landscape. INhouse's outdoor landscape demonstrates the possibility of the beautiful, vibrant surroundings one can have in California while still being conscientious about water usage.

SOLAR CAL POLY

A Contemporary California Aesthetic

Solar Cal Poly sought a balance between sustainable and experiential qualities, price, and performance in all of the materials we used. To achieve a contemporary California aesthetic, we have combined these elements in a mindful way to create comfortable, delightful spaces. Light colors and clean lines engender a serene backdrop to resident's lives. Through our chosen materials, we have accomplished an appealing contemporary California aesthetic, a long-lasting solution, and a thoughtful design.

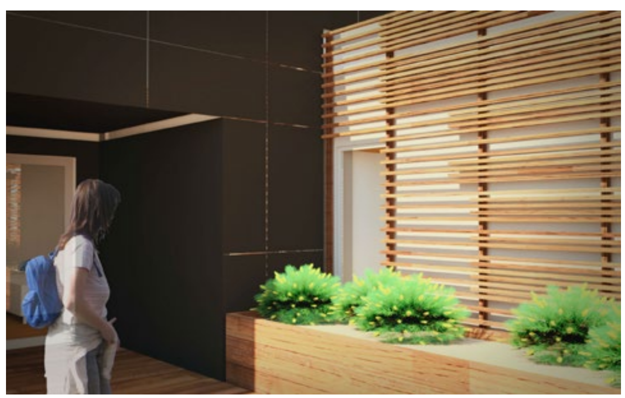
A delightful, durable, and comfortable home starts with the most basic construction. Our framing uses kiln dried lumber, which has a very low moisture content. This prevents the growth of mold and mildew, which can affect health. For the public and private wings, structural insulated panels (SIPs) provide a continuous thermal barrier, keeping the inside of the home at a consistent temperature. Additionally, SIP construction is fast, saving homeowners time and money. The expanded polystyrene insulation inside the panels allows for a well-insulated home and prevents environmental noise from leaking into the home.



Our core cladding material, Richlite® Rainshadow, is made from paper. The panels contain FSC® certified material and recycled content. Additionally, in the manufacturing process Richlite strives to ensure minimal energy use. The result is a material that is sourced and manufactured on the West Coast and meets the most stringent chemical emissions standards.

The exterior material on the passive public and private wings highlights one of California's most precious resources: redwood. The redwood screen, decks, and planters at INhouse are all FSC® certified and sourced in California, including some from Cal Poly's own Swanton Ranch. Redwood has a long life-span and when left unstained, it patinas to a beautiful gray. By not treating the screen, decks, and planters, we save the owners money and maintenance. When pieces of the screen or decks are no longer useful, they can be chipped and reused for mulch or other products. This would not be possible if they were treated.

Underneath the redwood, INhouse is clad with Hardie Panel®. This product is one of the most inexpensive panels on the market, yet it is durable, lasting for more than 50 years. Through its lifespan, it does not discolor or warp and requires no maintenance. This fiber cement board panel also contains FSC® wood. It is a safe, maintenance-free cladding with low cost.



On the interior of the home, the design goals were to provide joy, comfort and durability. Bamboo flooring is used throughout INhouse. Cali Bamboo® is made from FSC® certified bamboo. Bamboo is a durable and rapidly renewable resource, making it a perfect flooring material. In addition to flooring, bamboo plywood faces appear in most of the cabinetry throughout the home. The soft rich color adds to INhouse's inviting atmosphere.

We made a conscious choice to build INhouse of high quality materials and at the competition maximum of 1000 square feet because one of our primary goals was to ensure the longevity of the project. To accomplish this, we selected superior materials that focus on durability. Additionally, we chose to build a larger home to allow for future adaptability, as evidenced by the flexibility in the private wing. With these choices, the team was strategically thinking about the constructive use of INhouse beyond the competition period.

Interaction

INhouse is equipped with a network of built-in temperature, humidity, power production monitoring and power use sensors. This network is connected to a central, low-power server that collects data and feeds it to an application. Our application outlines data on the resident's smartphone or tablet in a simple format. By performing this long-term data collection, the network makes it possible to apply data-mining techniques in order to answer valuable questions about energy use of the home. Long-term monitoring allows home operation to be tailored to occupants needs and habits so the home operates at maximized efficiency.

In addition to monitoring energy use, INhouse utilizes a relatively simple yet effective lighting control system that allows the inhabitant to interface with their luminous environment. Inhabitants can control lighting levels through wall controls as well as remote devices, creating personalized scenes according to their needs. Additionally, the system supports remote access to the luminous as well as thermal environment through a smartphone application that controls lights and temperature.

The operability of INhouse extends beyond the mechanical systems of the house to its passive features. The spaces within INhouse emphasize convertibility, inhabitant comfort, and ease of use. In the living room, the 15-foot glass NanaWall® folds

open completely to create a large opening to the outside. Adjacent to the living space, the kitchen has remotely operable clerestory windows, which create cross ventilation. Additionally, the central core is taller than the rest of the house and has clerestory windows located at the top. This creates a stack ventilation effect that can ventilate the entire home, insuring that the kitchen, often the hottest room in the house, can be cooled. This flexibility allows inhabitants to take full advantage of a contemporary California home in its temperate climate in order to customize spaces to fit their needs.

Daylighting is an important strategy for Solar Cal Poly. We designed our glazing to provide ample light throughout the day to minimize the use of electric lighting. The clerestory windows in the core face north for multiple reasons including limiting heat gain,maximizing stack ventilation, and inviting pleasant northern light into the center of the project. The ceilings in the core are also shaped to be a light scoop, directing daylight down into the space. Most windows in the private and public wings are located close to walls, to direct light at the architectural surfaces thus increasing the amount of reflected light that enters the spaces. All windows are placed to maximize natural light, invite views, and minimize heat gain.

The bifacial room at INhouse was designed to shield inhabitants from the elements while offering adaptability to accommodate changing needs. During the summer the operable screen doors shade the deck space beneath the panels. In the winter, the screen on the south can slide to open the room to the light and warmth of the sun. The inhabitant is able to interact with the bifacial room screens in order to maximize their personal comfort in this space.

The decks are created to be enjoyed year-around, with plenty of space for a barbecue, lounge seating, and dining. The outdoor spaces of INhouse extend the living spaces and bring people together. In our temperate climate, the additional space afforded by the decks supplement the living spaces of an otherwise modest sized home.

INhouse is for people who want to take an active role in their home. All of the windows in the home are operable to allow for natural ventilation throughout. Versatility in the private wing and the outdoor decks create opportunities for customization. Our in-home application also allows users to track their energy production and consumption, control their thermal and luminous environment, and receive feedback on how efficiently they are operating their home. INhouse invites user control and interactivity, allowing inhabitants to adjust their home to their satisfaction and teaching them about net zero living in the process.

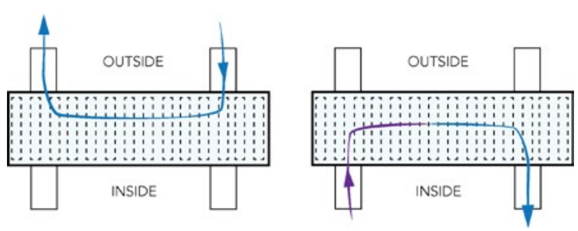
SOLAR CAL POLY

Unique Sustainable Features

Apart from the most significant energy conserving features of the home, climatic responsive design and attention to ecologically responsible materials, there are two unique design features that differentiate INhouse.

An innovative feature of our home is our phase change material duct [see diagram below]. This duct contains a palm-oil based phase change material that freezes and melts at approximately room temperature. During this process, it absorbs and releases energy in the form of heat. The duct opens to the outside at night and circulates cold air, which allows the material to cool. Then during the day, the interior air can be circulated through the duct, keeping the inside cool while reducing the need for air conditioning. As a result, the decreased heating, ventilation, and air conditioning load saves the occupants money.

An additional unique feature of INhouse is our use of bifacial panels, which make up half of our photo-voltaic array. These panels have photo-voltaic cells on both the top and the bottom of the panels. Bifacial panels collect most of their energy from the top, collecting additional energy from reflected light hitting the bottom of the panels. In addition to the increased efficiency, the panels allow the occupants to see how their home is collecting energy. The bifacial panels epitomize integration at INhouse, as these panels create a comfortable shady respite for residents while simultaneously generating power. As such, they tie aesthetics together with energy production to educate people about their home.



Attainable Green

Instead of being tied to a specific demographic, INhouse caters to individuals or couples who want to take an active role in their home. The sustainable features of the house invite involvement. Operable windows and mobile shade screens offer the chance for occupants to understand and participate in the home's functions, helping to save energy and money. A resident does not need to move into the home knowing how to operate it. An eager resident will soon intuit the rhythms of INhouse, learning the simple steps that will help them increase comfort while also save energy

For many of life's moments, INhouse provides flexibility. The flexibility of the spaces can accommodate overnight guests, large gatherings, and family living. In addition, with almost 700 square feet of outdoor living space, INhouse provides occupants with a seamless connection to the outdoors. The deck and bifacial room expand the living space and allow for large gatherings and entertaining.

Our home demonstrates "attainable green." INhouse is not equipped with the most expensive options, but instead balances cost, performance, and aesthetics. One example of this is our choice of mechanical systems. Instead of choosing the highest efficiency systems, which would be costly as well as oversized for our home, we balanced cost with efficiency to create a home that is functional and sustainable without being unattainable. We followed a similar concept for the finish materials. For example, on the inside, our pallet of bamboo and Corian® values durability and cost along with the aesthetic qualities of each material.

On the exterior, durability, maintenance and aging were very important considerations. We balanced these with the cost, sustainability, and beauty of the materials. We chose our pallet of redwood, fiber cement panels and paper composite panels through careful planning and consideration. These are all long-lasting and durable materials with sustainable certifications and content. An ecological home should be equally comfortable and attainable; our materials choices emphasize a balance of cost, quality, and longevity.

Client Characteristics	
Location of Permanent Site	A six county region of Coastal California from San Luis Obispo County to San Diego County
Housing Type	Single Family
Number of Occupants	1 - 2
Client Demographic	An individual or couple with an eagerness to interact with and adapt to the home
Client Annual Income	$100,000
Number of Bedrooms	1

Beyond the Competition

We are excited that our house has a place beyond the competition. We are currently in negotiation with clients to have the home remain on Cal Poly's campus and serve as student housing.

Once adapted to the landscape of Cal Poly, we will continue to monitor INhouse's energy generation and use. The residents of INhouse will be encouraged to learning how to live net-zero, and the house itself will be the vehicle of their education.

Learn by Living

The target cost of INhouse is $375,000 which would accommodate households with a minimum income of $100,000 per year. We worked diligently to stay within our target cost and provide a delightful home that meets our clients' needs. The team wanted to create a quality product that also minimized upfront cost and maximized long term savings. Achieving this balance required significant research and diligence but the team ultimately achieved its goals. With an emphasis on environmental responsiveness, INhouse is a project that exemplifies a balance of efficiency, quality, and cost.

INhouse saves clients money on energy and water, but it is more than just an efficient home. It demonstrates that by taking an active role in a home's operation, a resident can learn about the network of passive and active systems in the home and how to utilize these systems to their full potential. INhouse shows occupants how an intuitive, interactive, and integrated home can result in delightful living.

engineering.

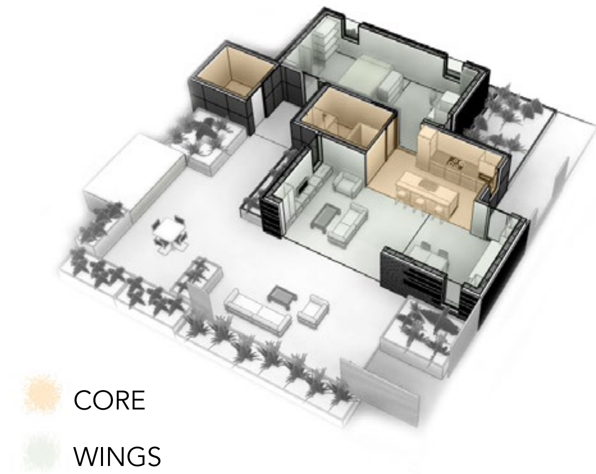
Engineering INhouse

INhouse is intelligently designed to respond to the conditions of the climate in coastal California, such that the majority of its needs for heating, cooling and lighting are addressed passively. The supplemental systems necessary for the remaining space conditioning, lighting, and power needs are efficient and effective.

The public and private wings are serviced by an active core that contains the home's mechanical, electrical, plumbing, and monitoring systems. The private wing includes a master bedroom and a flexible space which may serve as a library, office, or secondary bedroom space. The public wing incorporates entertainment and dining spaces with thoughtful linkages to the exterior spaces and the views beyond.

Striving to achieve the highest level of efficiency, INhouse incorporates both engineering analysis and innovative technology to design a highly efficient house that will then be actively monitored in order to advise residents on how to reduce consumption. To achieve these goals, the Solar Cal Poly engineering team took on the task of analyzing and designing the performance aspects of INhouse. Their finding were compiled into senior project reports which are listed in the Appendix. This included providing the architecture team with detailed energy building simulation results that were used to inform collaborative design and optimize the performance of the home. To facilitate this process, each performance aspect of the house was assigned to sub-teams of three or more students. These students became the experts on their assigned systems in order to develop the optimum intuitive, interactive, and integrated design for INhouse.

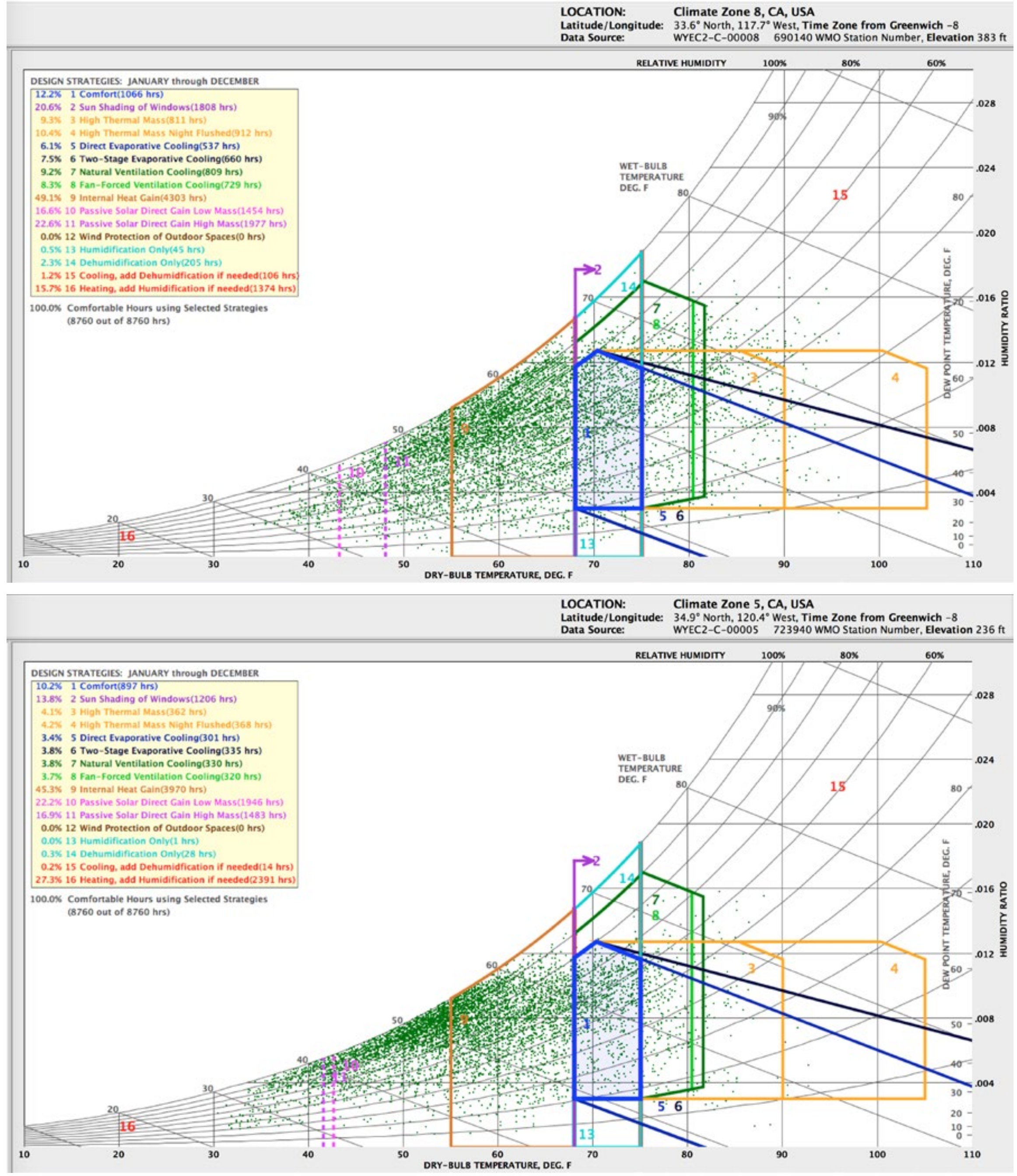
Comprehensive and thorough analyses guided all of our decision making throughout the iterative design process. In this narrative, we describe our analysis methods and findings directly within each of the topical sections because we found it to be more descriptive to discretely describe individual design elements with the analysis that informed each of those design decisions.



Climate Analysis

The design of INhouse is driven by climate and place.

In order to develop an integrated design we analyzed the climate of coastal California, encompassing a six county region from San Luis Obispo County in Central California to San Diego County in the south. These counties have a Mediterranean climate in which the ocean moderates the temperature year around, producing milder winters and cooler summers. An important factor in these climate zones is the diurnal temperature variation, the significant difference between the maximum and minimum daily temperatures. As the biggest energy challenge is providing and maintaining thermal comfort, we worked to design a project that works with, and not despite, the climate. We utilize the diurnal variation to passively cool INhouse at night. Additionally, we utilize other passive design strategies to emphasize the use of building design and material metabolism as the first response to providing thermal comfort. We then engineered innovative systems to support the passive strategies and create a cohesive and comfortable home.



Psychrometric charts for our site in Irinve, CA [top] and San Luis Obispo, CA [bottom] guided our analysis and design.

Energy Use

From the beginning, we worked carefully with the energy budget of 175 kWh while also understanding the tasks we are required to perform at the competition. To balance these, we gathered data showing nominal energy of each required item [right]. These values gave us a foundation for choosing our systems for INhouse. To meet the requirements, we had to consider efficiency and cost, but also how the systems would integrate into the home and into occupants' lives beyond the competition. By engineering an efficient home for the competition, we have also engineered an efficient home for a homeowner in coastal California. Over the course of a year, our home is expected to use approximately 400 kWh per month -- this does not include the electric vehicle as average national energy use reports do not include transportation. According to the U.S. Energy Information Administration, the average home in California uses 557 kWh per month which means our home reduces consumption by 28.2%.

Energy Production

The solar photovoltaic (PV) system for INhouse demonstrates how to integrate efficient engineering with the aesthetic potential of a solar array. In order to earn the total points for the Energy Balance competition, we need to produce 175 kWh during the competition. In order to safely meet this, the system was designed to output approximately 210 kWh during the competition which includes a 20 percent overhead. This setup is also optimal for yearly output, so the array would successfully power the home year-around on the California coast by producing approximately 15,044 kWh per year, approximately 1,253.6 kWh per month.

To accomplish our goal, we combined standard and highly practical monofacial PV panels with the unique transparent aesthetic of bifacial PV panels, which produce electricity from both the front and back sides of the modules, to create a system that highlights both efficiency and beauty. The monofacial PV array consists of ten panels that line the roof of INhouse's core and provide a total rated power of 4.35 kW of DC output. The bifacial PV array consists of 14 panels that are arranged on a canopy covering the south facing patio and provide a total rated power of 4.95 kW of DC output. In addition to contributing to energy production, these bifacial panels also provide diffused lighting to the deck below, increasing the comfort of the space. The monofacial and bifacial PV panels are each connected to separate transformerless grid-tie-inverters. The overall system performance has been designed to insure net-zero operation for both the competition and the final installation based on a likely range of weather conditions and the predicted performance of the house.

Energy Budget

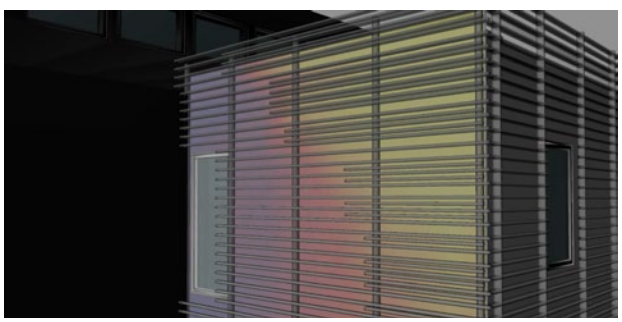
Power Draw	Hours for Task	Hours Used or # of Times Used	Kw per Hour or per Use	Nominal Energy Use
Refrigerator	191.5	191.5 Hrs	0.05 kW per Hr	9.58 kWh
Stove	13.5	5.5 Hrs	2.5 kW per Hr	13.75 kWh
Dishwasher	12.5	5 Times	1.25 kW per Use	6.25 kWh
Oven	24	4 Hrs	1.92 kW per Hr	7.68 kWh
Washing Machine		8 Times	0.3 kW per Use	2.4 kWh
HVAC				48.00 kWh
Inline Fan		40 Hrs		6.00 kWh
Mechanical Room Fan		0.75 Hrs	0.3 kW per Hr	0.30 kWh
Blackwater Pump		0.17 Hrs		0.21 kWh
Greywater Pump		0.17 Hrs		0.21 kWh
Lighting	26	26 Hrs	0.4 kW per Hr	10.40 kWh
Laptop	34	34 Hrs	0.06 kW per Hr	2.04 kWh
TV (32")	37	37 Hrs	0.03 kW per Hr	1.02 kWh
Control System				4.00 kWh
Vehicle (i3 or eGolf)	16 Hrs			58.50 kWh
Total				**170.34**

Passive Design

A major goal for Solar Cal Poly team is to incorporate passive elements into the design which reduce the active cooling load while providing a comfortable living environment. Since passive design is mainly focused on the placement of passive elements, we needed to determine the optimal size and location of each component. To achieve this goal, our team used several commercial building energy simulation packages such as Design-Builder, an interface for the DOE EnergyPlus energy modeling engine.

For our climate regions, shading the house is an important strategy to ensure optimal performance. The final design for shading the house is a integration of engineering and architectural concepts. INhouse is shaded in two ways: an awning on the south and a redwood screen on the skin. The screen is patterned as a solar thermal map of the house [shown below], with the denser areas indicating zones of higher solar intensity, and thus maximizing the efficiency of the shade screen. The awning integrates photovoltaic panels and sliding screens to allow residents' to customize the amount of shade to match their thermal comfort needs. These shading strategies reduce INhouse's cooling load and visually demonstrate a connection between architecture and engineering.

The next line of defense against heat gain in the house was to optimize the placement and size of the windows. INhouse is designed to maximize the

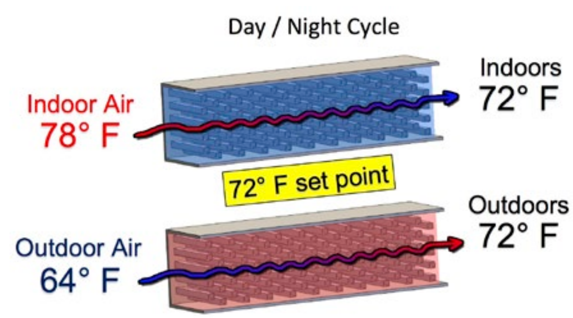


Shade-screen Cooling Load Reduction		
	No Screen	With Screen
South Zone	4.3 kbtu	4.0 kbtu
North Zone	2.2 kbtu	2.0 kbtu
ME Room	1.0 kbtu	1.0 kbtu
Core	3.3 kbtu	3.3 kbtu
Zone Total	10.8 kbtu	10.3 kbtu
Percent Difference	-	4.46% reduction

glazing of the house without allowing the excess solar radiation to drastically impact the cooling loads. Design-Builder energy analysis allowed us to analyze the effect of glazing location, U-factor, and Solar Heat Gain Coefficient (SHGC) to determine the optimum window specifications. Results from many iterations were compared to determine the optimum value of 0.3 for both U-factor and SHGC based on the location of INhouse in coastal California. We optimized our glazing design to maximize natural light and minimize heat gain by shading the south glazing and appropriately sizing the north glazing; glazing on the east and west is minimized.

The final element that contributes to the passive cooling design of INhouse is a unique and innovative utilization of phase change material (PCM). This system is based on the simple concept that material undergoing a phase change has the ability to store or release vastly more energy than single state materials of similar size. To allow for maximum efficiency, we maximized heat exchange. INhouse's solution involves a thermal energy storage duct where air is

passed over a staggered array of PCM cross-rods. The rods are made of conductive aluminum and filled with palm-oil based phase change material which freezes or melts around room temperature. This system cools recirculated indoor air during the day, which melts the PCM inside. At night, it is recharged using cool outside air, which solidifies the PCM for use the next day. This solution handles the base load energy required to stabilize the temperature swings that occur around a comfortable room temperature. The system is projected to reduce cooling loads by 8% during the competition.



SOLAR CAL POLY

Structural Insulated Panels

From past experience with the Solar Decathlon competition, the team determined early on that structural insulated panels (SIPs) would be used for most of the exterior walls of INhouse. SIPs function both as structural walls as well as insulation for the home. SIPs are essentially a sandwich of hard packed rigid insulating foam between oriented strand board sheathing. SIPs are ideal for a small house as they ease construction and provide maximum benefits to cooling and heating loads. The Solar Cal Poly engineering team used research and analysis to confirm that SIPs would be both efficient with regards to energy, cost, and ease of construction. Once confirmed that SIPs were the best option for the house, more detailed analysis was used to determine where SIPs would be used, the type of rigid foam insulation to be used, and insulation thickness.

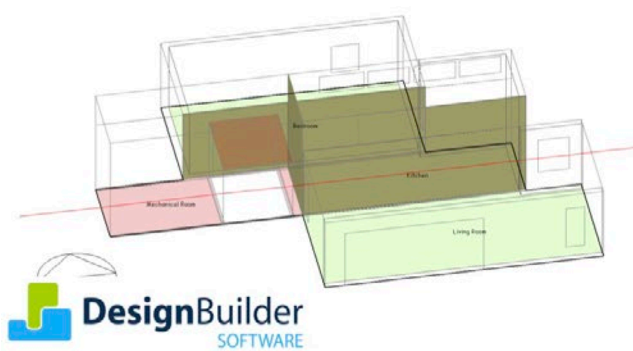
Design-Builder and ABAQUS (commercial FEA code) were the main tools used for the analysis. ABAQUS was used to confirm the projected insulator ability by calculating a thermal resistivity (R-Value) of the potential SIP sandwiches. Once the R-values of our proposed SIP layouts were confirmed, we used Design-Builder to conduct a complete heating and cooling model for the house based on historical weather data for both Irvine as well as San Luis Obispo. Design-Builder also allowed us to modify the location and amount of insulation used in the floors, walls, and ceilings. Our analysis demonstrated that using 8 inch expanded polystyrene SIPs for all exterior walls and roofing provided optimal performance. Using this design, cooling loads are kept well under one ton of refrigeration, allowing us to keep the heating, ventilating, and air conditioning portion of the energy budget to a minimum.

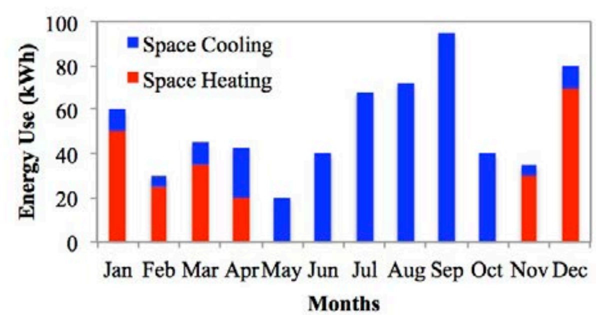
Active HVAC

The selection of the heating, ventilating, and air conditioning system (HVAC system) was guided by the design principle of INhouse. Our home is designed around a central core which contains all of the mechanical, electrical, and plumbing systems for the home and distributes them to the public and private wings. Given the insulated mechanical chase leading from the mechanical room along the entire length of the core, it was determined that a conventional ducted system was the best response for proper air distribution. The geometry and layout of the core allows for the design of a simple duct system with access to each room of the house. With this constraint determined, a split system consisting of an outdoor heat pump and an indoor air handler was selected. This system was favored as it is a modern and proven HVAC system that has been increasingly relied upon in the HVAC industry.

A heat pump was also favorable given the climate scenarios on the California coast, as it can still operate efficiently during the coldest temperatures experienced in the region. To meet the ventilation needs of the house, a heat recovery ventilator (HRV) was chosen to interface with the return side of the air handler. Designed using ASHRAE Standard 62.2, the HRV provides whole-house ventilation along with heat transfer to incoming outdoor air, thus improving the efficiency of the system. The intertwined system runs simultaneously to maintain the temperature and humidity of the interior.

Once a system was chosen, two commercial modeling programs, Design-Builder and Energy Pro 6, were used to verify the system performance. The model was constructed with three conditioned zones (bedroom, living room, and bathroom) in green below, and one unconditioned zone (mechanical room) in red below, for INhouse in Irvine, California. These models and programs provided location specific weather and atmospheric data, and helped to determine heating and cooling loads, energy consumption, and other performance parameters for each specified zone of the house. The HVAC system was sized based on summer weather conditions in Irvine. The heat pump was conservatively sized to provide 1.5 tons of cooling capacity, which is 1.5 times the design load calculated in Design-Builder. The results also facilitated the use of a single, centrally located thermostat. Due to the increased thermal load in the living room, flow dampers were integrated within the duct system to provide varied flow rates to the different zones in order to maintain a balanced temperature throughout the house.

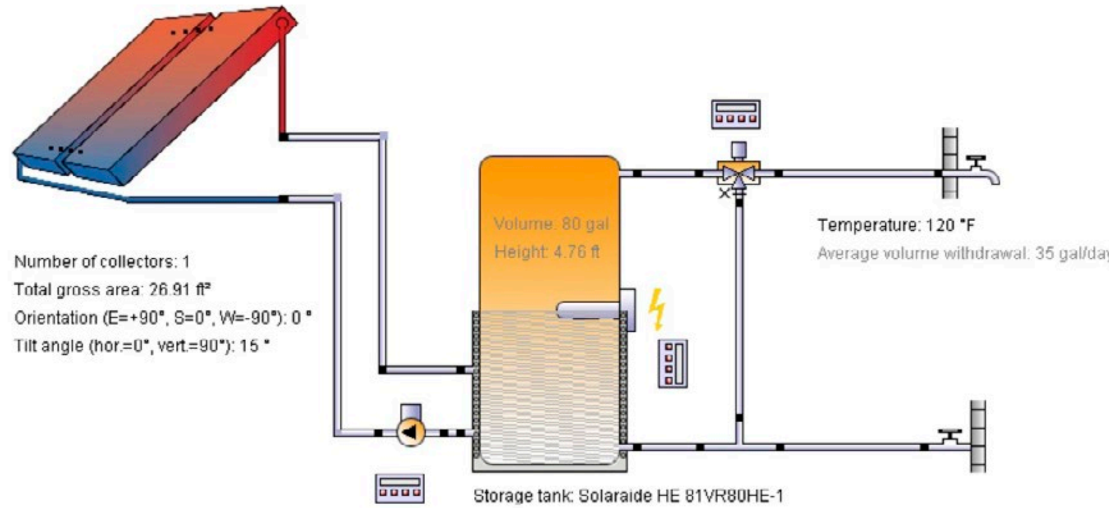




SOLAR CAL POLY

Solar Hot Water System

A solar thermal flat plate collector system was selected to produce hot water for INhouse. The system sizing was determined using commercially available F-Chart analysis software which the team used to calculate monthly and annual energy collection for both Irvine and San Luis Obispo. The selected system consists of a Heliodyne GOBI flat plate solar collector, Heliodyne Helo-Pass heat-transfer appliance controller, and Rheem Solaraide hot water storage tank [schematic below]. The system has been sized for a solar fraction of 86% in Irvine and will provide most of the hot water needs for the competition based on a typical year.



Plumbing and Piping

The plumbing team built upon conventional plumbing system standards and optimized a functional design for INhouse. The plumbing system needs to supply comfortable and reliable amounts of cold and hot water for contests during the competition and year-around for the future residents. The system also disposes of liquid waste, differentiating between gray and black waste for reuse and disposal, respectively. Through testing, system analysis, and simulation the team was able to ensure functionality and instill a high level of confidence in the efficiency of the design. Sub-designs include the supply pipe layout, piping material, heat recovery system, grey and black waste lines, sprinkler system, and hot water tank design.

Water Systems

The waters systems team was responsible for designing the system that supplies pressurized fresh water to INhouse as well as disposing of any grey and black water coming from the house. In order to mimic the municipal water lines, we need to pressurize the fresh water lines going into the house. To do this, we include an intermediate pressure tank between the fresh water supply tank and the house. This is able to keep pressurized water in the lines without having to turn the system on and off each time water is drawn from the house.

Due to the regulations of the California Plumbing Code on black water, any water coming from the toilet, kitchen sink, and dishwasher must be sent directly to a black water storage tank. The grey water coming from the bathroom sink, shower, and clothes washer has fewer regulations. These state that the water must remain at a minimum of 4 inches below the surface of any water treatment system and have a valve to divert water to the black water storage tank. These regulations were carefully considered and followed through the design of INhouse's water systems.

In order to keep the house as environmentally friendly and water-conscious as possible, the water systems team devised a method of reusing grey water for various useful purposes. The final design includes a constructed wetland which allows the homeowner to reuse greywater for irrigation to any landscaping. The three-celled wetlands are filled with 3/8 inches of gravel and topped with California native plants, their roots extending down through the gravel. The greywater flowing through the gravel creates a region for microorganisms and beneficial bacteria to cultivate, leading to better filtration of the water before being used for irrigation. The size of the wetlands is optimized to allow for sufficient filtration of the water while maintaining a cohesive exterior aesthetic layout.

Constructed Wetlands Design Targets	
Requirement	Target
Effluent BOD levels	less than 20 mg/L
Effluent TSS Levels	Less than 20 mg/L
Surge Protection - Water Level	Less than 2 inches below the surface
Energy Usage	Less than 0.03 kWh per day
Footprint	Less than 75 square feet
Design	Integrated with the landscape

SOLAR CAL POLY

Appliances

The goal for the appliance selection was to balance cost, performance, and aesthetics. To meet the performance aspect, we selected all items with Energy Star ratings where applicable and then filtered them based on the optimal low energy use and water consumption as well as environmental impact. We also wanted to ensure that we met the Solar Decathlon 2015 competition criteria for various tasks that require appliance use, such as washing laundry, hosting a dinner party, or taking a shower. Because each house is only allotted 175 kWh for the nine days of competition, the appliances were carefully analyzed to determine how much power and water each one would require to ensure that we could complete the competition tasks with the allocated resources. Additionally, future use of the home was considered as we chose appliance that would provide a delightful and functional home for residents.

Electric Car

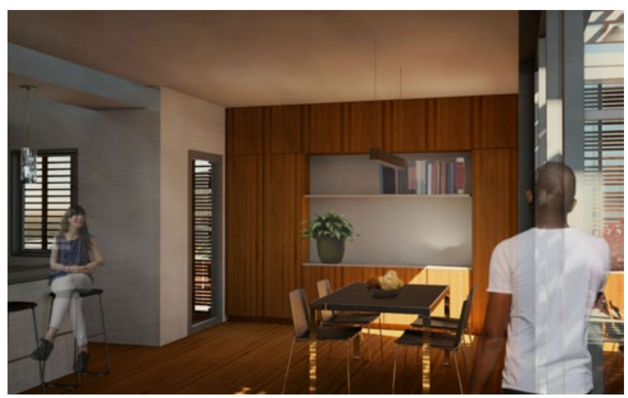
Charging an electric car is very energy intensive; the charging of the electric vehicle is expected to be our single biggest electrical load, which can be seen in the energy budget bottom right. As such, we carefully analyzed the efficiency of commercially available electric vehicles for the commuting task of the competition. To minimize the amount of energy charging our electric vehicle will use, we have chosen to use one of the most efficient electrical vehicles on the market. We will be at the competition with the BMW i3 or VW eGolf based on which vehicle is available to us at the time of the competition.

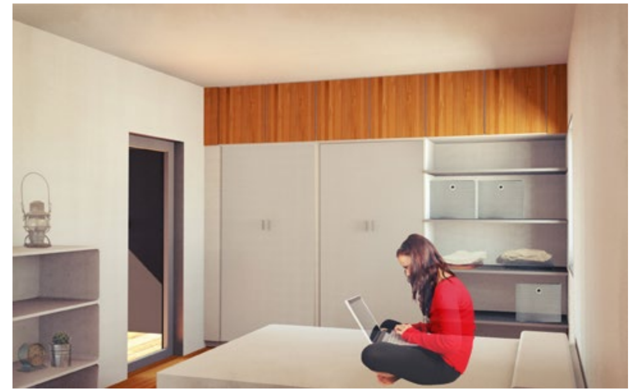
Lighting

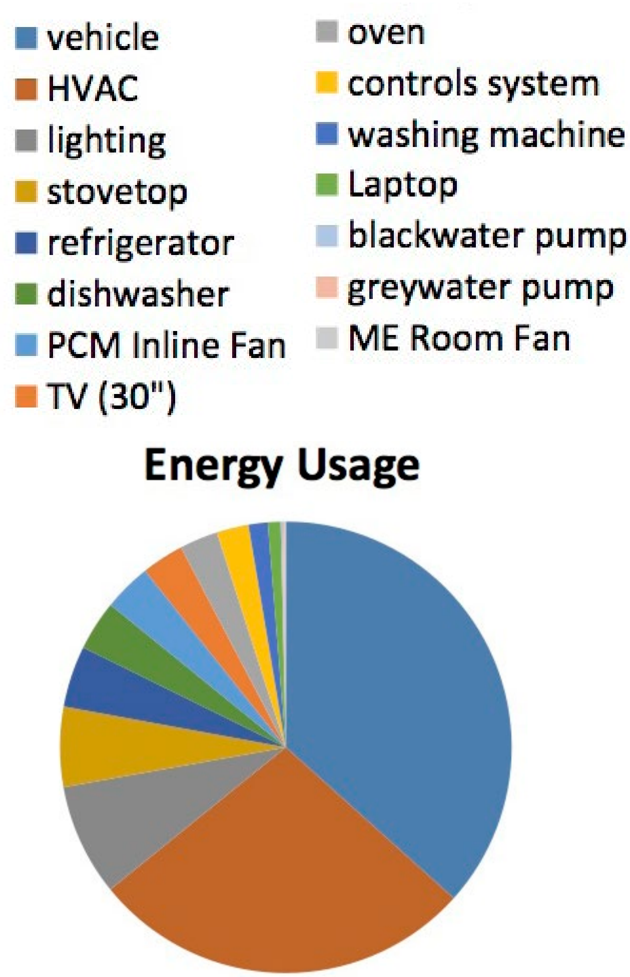
Creating a delightful luminous environment is a goal of INhouse. Daylighting is the primary method of achieving this goal as it is pleasing as well as energy efficient. The electric lighting combines with the daylighting in a cohesive manner in order to be efficient, enjoyable, and functional. All of the electric lighting sources are color-consistent and highly efficient LED fixtures. INhouse manages to achieve quality lighting design while consuming only about .5 watts/foot of energy.

Lighting and Temperature Controls

INhouse is equipped with a Lutron® Caseta global lighting and temperature controls system. This system allows residents to customize their luminous and thermal environment according to their changing needs and desires. Through a smartphone application, residents can control both lights and temperature setting remotely. This application along with INhouse's custom monitoring application outlined below, gives an engaged resident the potential for efficient optimization of INhouse's energy consumption.







Instrumentation and Controls

The instrumentation and controls team designed and built an instrumentation and control system for INhouse. The system contains various sensors including temperature, humidity, power usage, and power generation. The data is collected at a high level of granularity, as temperature and humidity are provided on a per room basis, power generation values for each of the two solar technologies used, and power consumption for each appliance and light. The sensors relay data back to a central database which operates independently, providing constantly refreshing data to the application. In addition, the data can be mirrored on the cloud, allowing for users to monitor data remotely. The system relates this information to the user through a tablet application developed by the computer science team.

The system also optimizes the PCM duct. It monitors the PCM duct by measuring the temperature of the PCM, the exterior temperature, and room temperatures. Then the system, uses this data to determine when to open and close dampers and turn on the fan in the duct.

To meet all of INhouse's needs, the monitoring system hardware has been carefully planned. The system uses an Arduino MEGA as the central controller for the monitoring system because it runs on a 16 MHz clock, has four UART ports to communicate with the sensor clusters, and relies on a familiar operating system. The sensor clusters are composed of a temperature and humidity sensor, an Arduino Mini PRO, a gang-box and a custom laser-cut wall plate. The Arduino Mini PROs communicate with the Arduino MEGA via CAT5e cable, which runs underneath the house. A Raspberry Pi B+ database stores the temperature, humidity, and energy usage of INhouse. Information from the Raspberry Pi is displayed on the tablet application developed by the computer science team. At the competition, a Nexus 9 tablet will be used to displays all of the collected data. Beyond the competition, residents will be able to use the application on their own Android device.

Software Design

INhouse is designed with flexibility in mind and allows residents to make adjustments to optimize their comfort while minimizing energy use. To assist occupants, INhouse has a custom application. Designed by the computer science programming team, the INhouse application provides a variety of features to enhance occupant comfort and control. The user is provided multiple graphical methods for observing data including pie charts, energy consumption values displayed on the floorplan, and line graphs which provide historical data for both consumption and generation. The user can analyze the data in different categories such as viewing consumption rates per room, per appliance, or by seasonal and hourly differences.

The first division for the application displays power production and power usage. The climate section provides regional weather information as well as data from temperature and humidity sensors in the house. This information assists the resident in decisions that can passively improve their thermal comfort. The weather data can be used to decide whether to open the windows or close the blinds.

An additional division provides users with recommendations and alerts. This section algorithmically analyzes data from both inside and outside of the house, such as outdoor temperature, time of sunrise and sunset, and wind speed and direction. Through this analysis, the application is able to give residents recommendations about efficient options to maintain their comfort. For example, the application might suggest opening windows at certain times to reduce power consumption or it may alert users to a faulty solar panel causing an abnormal drop in power generation.

The objective of INhouse's customized application is not to control the house through technology but rather to employ computing to assist residents through data analysis. It teaches residents how to live net-zero so that they can understand how to live comfortably as well as sustainably. The goal is to educate the inhabitants so that they understand how energy is being generated and consumed. We want the inhabitants of INhouse to understand how these rates are affected by variables such as temperature, humidity, and time of day so they can learn how to operate the house more efficiently. The application is there to provide suggestions as computers can easily discover efficiencies that humans may not anticipate.

INhouse - Learn by Doing

The Solar Cal Poly team could have designed a house that operates entirely independent of its residents, but a "smart home" is of less value to society than a "smart resident." Through the engineering and design of INHouse, we have taken a holistic approach which stems from the shared vision and close collaboration between the many disciplines involved in the project. Residents of INhouse will be encouraged to learn how to live net-zero, and the house itself will be the vehicle of their education.

By balancing sustainable and experiential qualities, cost, and performance, the Solar Cal Poly team presents a new standard of "in" by engineering a notion of ecological living that is enticing as well as achievable. INhouse is an approach to living well, while still living within our ecological means.

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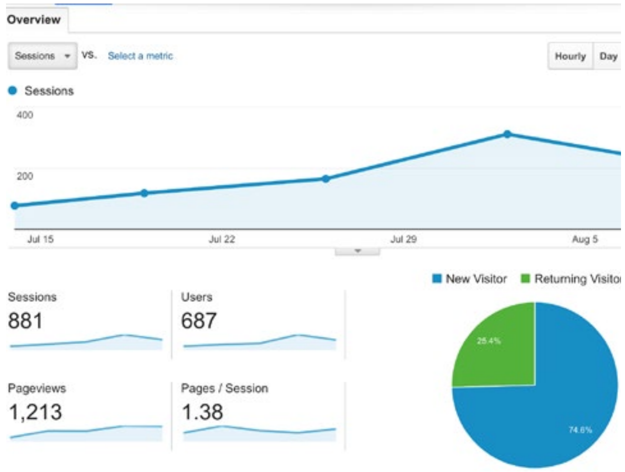
communication.

INhouse

Solar Cal Poly began as an initiative of the Renewable Energy club (REC), a group of Cal Poly San Luis Obispo students passionate to explore a deeper meaning of sustainability by collaborating across disciplines. From the very beginning of the project, the team's mission has been to create a home that meets both the residents' and society's need for ecologically responsive housing while simultaneously creating an environment that delights the resident both experientially and thermally. Through a rigorous iterative design process involving students, faculty, alumni, community members, and sponsors, the concept of INhouse emerged over time. INhouse is a manifestation of Cal Poly's core mission, "Learn by Doing." By drawing on our school's unique identity as a polytechnic university, our multidisciplinary team accomplished all aspects of designing and building "in-house".

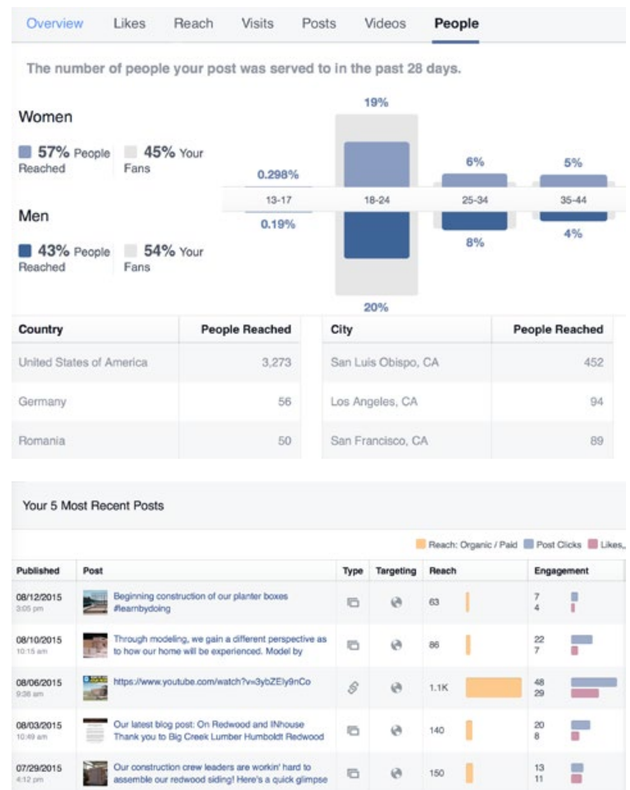
Without an initial commitment to a final site or client after the Solar Decathlon competition, the team designed INhouse with adaptability in mind. In the process of design, adaptability evolved into the the project's three "I's": intuitive, interactive, integrated. These guiding words embody the team's ideals as we demonstrate that achieving net zero design requires a partnership between the home and resident: a smart home needs an active resident willing to engage in order to achieve a net zero goal. Team Solar Cal Poly's communication objective is to demonstrate to a multigenerational audience that conscientious engagement with our built and natural environment is imperative. In the case of INhouse, an engaged and committed "smart resident" is essential to the success of a "smart home."



A Foundation for Communication

With over 100 team members throughout the project, organizing and communicating with all students, faculty, and administration has been a dynamic process. The team shares files and resources through Google Drive. Our primary student contact sends weekly messages to the team through a visual MailChimp template. Weekly all-hands meetings are held to discuss updates between all disciplines involved. Our website is custom-coded to fit our visual-based needs as all of its components including the blog are neatly packed into an infinite scroll format. We use the website to share our overall message with the public, which is updated weekly. The website is monitored through Google Analytics [above] to track how engaging it is with viewers.

For updates on current progress, @SolarCalPoly and #SolarCalPoly utilizes the social media platforms Facebook [right], Twitter, Instagram, Flickr, and Youtube. Social media can be updated as many times as necessary per week. By having access to Hootsuite Pro, the team is able to use analytics tracking and schedule Twitter and Facebook posts ahead of time to ensure a time-savvy and multi-user social media strategy. The Hootsuite Pro platform also allows us to easily track the progress of our competitors and stay in the loop on updates from our sponsors.



[above] Facebook allows us to see information about our followers and posts.

Targeting a Multigenerational Audience

Team Solar Cal Poly has been working directly with the College of Architecture & Environmental Design's External Relations Office to promote our message to alumni. At the beginning of the project, a student team performed a marketing analysis to determine the best method of reaching and engaging alumni of all ages. Understanding this data, the team developed methods to gain alumni support through multiple campaigns utilizing phone calls, postal mail, email, and face-to-face presentations. Our sponsorship team has traveled to nine different California locations, from San Francisco and Sacramento to Irvine and Solana Beach, making presentations to Cal Poly alumni and interested supporters about the team's goals, design, and progress. All people who have attended a sponsorship event are added to a 200+ member list of "engaged supporters." The team sends an interactive Mail Chimp email to these supporters on a bi-weekly basis, ensuring that they stay up to date on team progress and opportunities.

In order to reach a support network beyond the college, Solar Cal Poly has been engaged with activities in the local community and beyond. The team led two interactive workshops teaching local elementary school students about passive solar design. Solar Cal Poly explained our design to people of all ages at the San Luis Obispo County Earth Day and the City of San Leandro's first ever Solar Week. The Solar Cal Poly story has been shared by team leaders at the California Higher Education Sustainability Conference 2015 as well as the AIAS Grassroots Leadership Conference 2015 in Washington, DC. The team was featured in local magazines, radio interviews, and news reports to highlight important moments throughout our progress.

At the Competition

We plan to share INhouse's mission by using digital as well as analog media during the Solar Decathlon competition to engage a multigenerational audience. The public handout has been designed to stimulate curiosity for visitors with its hidden fold lines that when assembled, will create a pop-up replica of our home. The team has chosen symbols that represent the home's innovative features and minimized text to ensure that even young children and non-English speakers will comprehend our message. The public display boards tell a story about our home's relationship to its environment and inhabitant.

During the competition, the communications team will actively update our social media accounts, blog, and website with photos, videos, and information about our performance. Cal Poly students and alumni will be trained as tour guides before the competition through a live video presentation. Through these presentations, we will educate our tour guides on the features of the home to ensure that we maintain a consistent message.

Success beyond the Competition

Just as the Solar Cal Poly story began as an initiative of the Renewable Energy Club, its story will continue through REC. The Solar Decathlon's curriculum structure will be available as a guide for future multidisciplinary sustainable design-build projects at Cal Poly. We are currently in negotiations to use the home for on-campus housing after the competition. Once adapted to the landscape of Cal Poly, residents of INhouse will be encourages to learn how to live net-zero, and the house itself will be the vehicle of their education. The home will continue to be monitored by REC with reports and statistics published on our website and social media as we learn from our results.

The team will know if its communications strategy succeeded after the competition if alumni and industry engagement with the university has increased. Solar Cal Poly intends to cultivate a multigenerational following of people who seek Cal Poly's assistance for holistic solutions for future sustainable design-build projects.