Zero Net Energy Tiny House Manual

Guidebook for Design and Construction

CALIFORNIA COMMUNITY COLLEGES
Doing What MATTERS™
FOR JOBS AND THE ECONOMY

by Thomas W. Rettenwender, et al.

UC Santa Cruz, Tiny House Design Lab offers hands-on, project-based training. Design and practise empowers students with confidence to realize their visions and goals. The job skills learned give students encouragement to take on the complex challenges of creating affordable and transient living solutions.

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I What is a Tiny House ?

A Tiny House is a custom-built, small dwelling unit built on a trailer to enable portability and flexibility. The Tiny House Movement is an architectural design trend advocating a simplified, energy efficient and flexible lifestyle. Homes can be built on a trailer for easy transport or removed from the trailer for semi-permanent installations. Tiny Houses have strict size limitations, specific structural requirements and, at the same time, offer many advantages.

- **WHAT IS 'ZERO-NET' ENERGY?**
  Zero-net Energy implies that the dwelling produces the same amount of electrical power that it uses. This is usually done with a solar photovoltaic powe system. By 2020, California Energy Code plans to require all new homes to be Zero-net Energy.

- **WHY LIVE IN A 'ZERO-NET' TINY HOUSE?**
  An Zero-Net Tiny House is designed for self-sufficiency in electrical power, water and other resources. It allows for a portable off-grid lifestyle as well as comfortable live/work options for the high-tech enthusiast. Compared to conventional homes, these homes can achieve a much smaller carbon footprint over the life-span of the dwelling.

- **PORTABLE LIVING**
  Built on wheels, your house is not tied to a fixed location. It can be attached to a car or truck and transported to a new location. There are strong similarities to the popular RV - or recreational vehicle - market. Also similar to camper trailers. These transient forms of housing are ingrained in American culture. The west was pioneered by the horse drawn carriage and that same spirit of transience is still a major driver of American culture.

- **AFFORDABLE**
  Housing prices in Central California are out of reach for many. For others the only way to purchase a house involves committing to paying a 30 year mortgage. This results in interest payments almost equal to the original purchase price - essentially doubling the price. For example the median home prices in Santa Cruz County reached an all time high of $868,000 in Spring 2018 and these prices are climbing steadily. Rental prices are extremely high if available at all. For many, living in a tiny house offers an opportunity to reduce debt in order to have more time and flexibility for other things.

- **CUSTOM DESIGN**
  In opposition to traditional low-cost housing like trailer homes, campers and RV's , the Tiny House tends to be unique custom designs, built by hand and uses reclaimed materials. In many cases the owners of tiny houses have conceived of the design preferences based on their lifestyle and needs. Being involved in the design process offers enhanced pride of ownership. Additionally, there is the pride of having built the house from scratch understanding every detail.

- **BENEFITS OF 'SWEAT EQUITY'**
  Tiny Houses can generally be built using basic construction skills with basic carpentry tools. This allows people to build them by themselves or with the help of friends or family. One rule of thumb states that the labor costs of a traditional house are generally two-thirds of the cost of building a home. Consequently, this means a potential to reduce the cost of construction by two-thirds.

- ZERO-NET ENERGY EFFICIENCY
  Living on a small footprint mean less area to heat, cool, illuminate. With the zero-net energy code revisions coming online soon we can greatly reduce our power demand by living in smaller spaces. Tiny Houses that do not depend on the electrical grid have no choice but to be zero-net energy since the power used must be created by the on-board power systems. These same principles will apply to other residential zero-net systems. This fact makes off-grid tiny house power systems great case studies for optimization and and teaching purposes.

- LESS BUREAUCRACY
  The regulatory costs of building a traditional home are very high and have been increasing quickly in recent years. Tiny Houses are currently not considered single family dwellings by zoning administrations since they don't have a permanent foundation. While the trailer needs to be registered with the local agencies like the Department of Motor Vehicles, what goes on the trailer is a matter of personal preference or needs. This does not mean that designing and building a tiny house is easy. This type of structure has very specific challenges and does need to follow the Recreational Vehicle Industry Standards using American National Standards Institute ANSI A119.5.

California Community Colleges
Chancellor's Office

This design manual is intended to be a good starting point for anyone wanting an introduction to the Tiny House design, construction, and engineering process with an emphasis on achieving a zero-net energy balance. It can be useful for individuals and also relevant in a classroom environment for instructors wishing textbook.

ACKNOWLEDGEMENTS
Special thanks to Catherine Ayers, Bruce Greenstein and Jamie Orr for their support to make this happen with funds from the Energy, Construction & Utilities DSN grant at Foothill College. Special thanks to University of California, Santa Cruz, Prof. Ronnie Lipschutz, Kevin Bell, and the Sustainable Systems Research Foundation, who share a passion for the creative and economic benefits of the Tiny House Movement. Special thanks to Kieron Connolly, Dr Ingrid Thompson and Daniel Ramirez Jr. who supported the San Jose City College MIKRA House in its infancy but passed away before its completion. Special thanks to Caterina Di Giorgio for help with layout and cover page art work. Last but not least, thanks to my colleagues at the Ecologic Design Lab. Above all, Constantine Papachristopolous deserves immense gratitude for the years of inspired painterly collaboration.

DEVELOPMENT OF THIS MANUAL WAS SUPPORTED BY
Bay Area Deputy Sector Navigator for
Energy, Construction & Utilities
California Community Colleges Chancellor's Office
'Doing What Matters for Jobs & the Economy' 2016-2017

CALIFORNIA COMMUNITY COLLEGES
Doing What MATTERS™
FOR JOBS AND THE ECONOMY

I Introduction : The Tiny House Movement

With all the recent interest in and media about tiny houses, small dwellings on wheels, we are seeing the start of a movement. This movement is a response to several pressing factors. We, in Central California, find ourselves in another housing crisis due to a shortage of affordable housing. We are also faced with the need to become more climate resilient and find less wasteful ways to live. We are also seeing cultural shift accompanying a new millennium where fundamental concepts of 'living' and 'home' are evolving. Given these trends, the Tiny House Movement has just begun.

AFFORDABLE HOUSING

When trying to find solutions to the current housing crisis many turn to the tiny house. The smaller size, lower reliance on site infrastructure, and ability to 'do-it-yourself' are factors that can contribute to cost savings. Building and zoning codes are being adapted to incorporate this trend and need for smaller more affordable dwellings. The State of California has launched a pilot program in San Jose. Transitional 'Bridge Housing', as the name suggests, are meant for people in transition who will eventually find a more permanent home. Given a smaller footprint these units can be easily arranged into villages to house a larger number of people.

Building a community around affordable housing allows residence to share resources and support each other in many ways. It 'takes a village' to solve the housing crisis.

SPACE-SAVING DESIGN

Along with the smaller size and portability of the tiny house comes the need to use all the space available. We use the technique of 'stacking functions' to try to maximise the usefulness of all surfaces. By using 'space-saving design' we can use the same space in multiple ways by building folding or moving furniture, loft spaces, spaces underneath and above the house.

ZERO-NET INDEPENDENCE

Beyond being efficient, these dwellings have to be designed to be self-sufficient in order to reduce dependence on costly site utilities and infrastructure. Concepts of self-sufficiency and zero-net energy are being incorporated into upcoming building codes such as the 2019 California Building Code. We know that in the future we will be required to design and build our homes to be so efficient and self - sufficient that they can power themselves. Consequently the tiny house format offers an excellent case study for the future of zero-net architecture.

IN THE FACE OF CLIMATE CHANGE

Especially in the face of climate change, these steps toward efficiency and self-reliance are important in our search for more sustainable housing solutions. The current US housing stock uses about 50% of our total energy. This power, when produced in centralized power plants and transmitted to the end user many miles away, can lose 90% due to losses and inefficiencies in the production and transmission systems. By designing our homes to be more efficient and self-reliant, we can eliminate this huge draw on power infrastructure and the associated waste.

THE HAND-MADE HOME

Another reason the Tiny House Movement has gained in popularity is because of its diversity and accessibility. This is due to the notion that we all can build them ourselves. Anyone with basic construction skills, tools and access to Youtube can become a tiny house developer. The 'hand-made' nature of the Tiny House Movement gives rise to a colorful spectrum of custom-built dwellings based on the designer/builder's vision and ingenuity.

FLEXIBILITY

There is also a trend of using a diversity of materials in Tiny House projects. Along with the ability to build your own, you can also adapt the design to incorporate alternative materials. We have the ability to incorporate found and/or recycled materials. The building methods used are usually failry conventional, so these structures become easy to alter and adapt. In many tiny house projects the materials used have a history. This adds to the novelty, the character, of the final result.

21ST CENTURY NOMAD

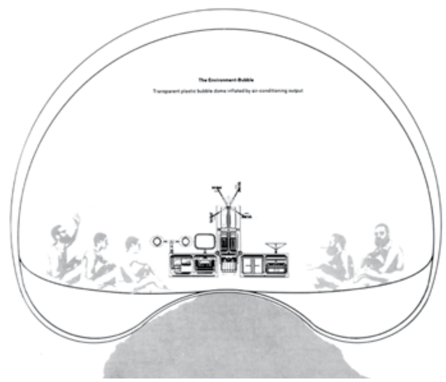
The Tiny House Movement also addresses lifestyle changes we are seeing at the start of this new millenium. A main-frame computer used to take up a whole warehouse. Now, that computer power fits in your back pocket. Renewable power has become so accessible, making the dependence on large scale corporate power grid unnecessary. We are also moving towards more shared economic models. Your house can double as a vacation rental or offer rooms for rent. Your car can become a taxi or shared with others. Office space is also being shared more frequently. With these trends in consuption we have more opportunities to share our spaces and environments.

SOCIOLOGY

Although the technology to live sustainable, low - impact life styles is readily available, the boundaries to carbon-neutral living are primarily behavioral. Our habits and customs remain the biggest hurdles to sustainable living. It is the adoption of sustainable design techniques, the sociology, that is the most difficult to enact.

THE EVOLVING CONCEPT OF HOME

Never before have has technology offered more options for independence from site, climate and environment. We see the visionary and ephemeral architecture of Super Studio and Reyner Banham more relevant than ever. The advent of the shared economy may offer ways to circumvent traditional forms of ownership. With technology and economies offering new forms of living and sharing, the whole concept of the 'home' is also evolving. We are less dependant - less tied - to the land than ever before. These trends can lead to greater sense of community as we become less reliant on large-scale patterns of ownership.



From "A Home is not a House", by Reyner Banham and François Dallegret, 1965

"Life, Supersurface" by Super Studio, 1972

NEW OPPORTUNITIES

The practical, climatological, as well as sociological benefits of the Tiny House Movement are leading us in new directions and offering new opportunities. These sociological and scientific challenges we are facing will only become more acute as this century unfolds. For this reason we are just seeing the beginning of a movement.

I Introduction : The Tiny House Movement

Often it seems like our society is 'at sleep at the wheel', blindly speeding to its own economic and climatological self-destruction. The birth of Tiny House Movement reminds us that technology, as well as, contemporary living trends are available to us. Adopting these trends will only become more relevant and frequent as the driving factors become more acute. Along with this trend we have the opportunity to revisit or rediscover the benefits of living in community, being self-sufficient and sharing resources.

This Zero-Net Tiny House Manual, is an attempt to illustrate some of these opportunities. The prototypes featured here are designed and built examples of compact portable dwellings. They offer innovative architectural solutions like walls unfolding to double living area, a house that rotates to capture the sun's energy, dwellings that are a mobile lab that sees sleeping as an occasional past time not the determining factor for an interior.

Taking these housing units one step further we explore how these small units can assemble into villages and form wholistic intentional communities. These constellations begin to address critical trends like the housing shortage crisis. As the Tiny House Movement blossoms we will be able to push this innovation further to explore the benefits of low-impact portable housing and the communities they enable.

In an attempt to locate these trends in history, we look at iconic examples of portable living of the past. Every relevant design analysis has to honor and learn from precedent examples. By searching this work of the past we find influential visions for the future. By learning from these visionaries we make sure our work is aligned and relevant to sociological trends. We also gain insights how our present day developments still fall short of these 'ecotopian' ideals. Ultimately we find evidence that the Tiny House Movement is in its infancy and here to stay.

Toyo Ito
Dwelling for a Tokyo Nomad Woman
1985 and 1989
Suspended Dwelling,, Tea Stand, Make-up Stand and Axonometric Drawings

2 Tiny House Case Studies

2.1 MIKRA House - San Jose City College

SJCC Mikra House was generously supported by

- San Jose City College, Business and Workforce Development & Career and Technical Education Program (CTE)
- Perkins Funding
- Proposition 39: California Clean Energy Jobs Act
- Sacramento Municipal Utility District
- Mathew Welsh at Earth Electric
- OBC Cork
- Premier SIPs
- SJCC Robotics and Automation Club
- EcoLogic Design Lab

The MIKRA House was designed at the EcoLogic Design Lab by Thomas Rettenwender and Constantine Papachristopolous. It was constructed at San Jose City College with a colaborative team from the Facilities Maintenance, HVAC and Construction Departments. It was designed with an urban and 'techy' setting in mind and is an urban tiny house prototype as well as an educational display. It is an exploration of the limits of the buildable envelope and a study of prefabrication with the use of SIPs panels manufactured at the Premier SIPs factory. The exterior texture and roof membrane is spray-on cork stucco, a wholly natural product. MIKRA is also a good example of an automated smart home where the building facade, structure, and appliances are operable by voice control, cell phone, touch screen, as wells manual buttons.

BUILDABLE VOLUME

The Tiny House format is, by definition, limited in size due to its foundation being a trailer and its requirement to be road-worthy. DOT guidelines specify that the maximum trailer size for transportation without a permit is 8'-5" wide and 13' 6" high. Consequently, the MIKRA House fits to these maximum dimensions but then exceeds the relative floor area by adding a loft and three wall panels that fold out mechanically. Given the trailer length of 16 ft. this means a max. building footprint of 136 s.f. Adding a loft allows for another 116sf (with 20sf for the ladder access). With the three automated wall panels we add another 155 sf. This turns a 136sf building footprint into a total of 407sf of usable floor space, which means an increase by a factor of three.

PREFABRICATION

The structure for the MIKRA House was prefabricated by Premier SIPs based on our provided design. SIPs is short for 'structural insulated panels' which use two sheets of plywood and foam insulation to generate a structural panel thereby avoiding the need for internal framing.

AUTOMATED BUILDING FACADE

Three wall panels totaling 155 sf of floor area unfold, with the touch of a button, to create additional floor space and facade openings. These wall panels can be operated using the on-board control system, with manual buttons or with a mobile app programed for the MIKRA House. Consequently the house can adapt to weather conditions and depending on use. The additional wall panels can serve as additional bedrooms, additional living room space or be opened for added ventilation and views. This flexibility emphasizes the adaptability of the tiny house concept, breaks the boundary of size limitations and is a good example of 'smart' home automation.

MIKRA House is a comfortable dwelling that doubles as a teaching tool and smart home automation display. Zero-net energy system, automated wall panels, surface mounted wiring, grey and rain water systems show a real life example of sustainable low impact living..

WALK THE TALK

With material costs around $25,000 this model can eliminate the need for a large mortgage. A smaller house reduces energy consumption and utility costs. Power comes from the sun with solar photovoltaics so there is no electricity bill. Off-grid live/work dwelling sleeps up to 5. It is also a full-scale teaching tool for research and display. MIKRA will continue to serve as a full-size mobile teaching lab at San Jose City College - Emerging Tech & Facilities Maintenance Tech and Construction Tech Departments. It will allow future students to learn from and adapt the installed systems. Instructors and students in related programs will continue to development, research and design improvements. W will travel to local high schools, colleges and conferences.

Mounting the SIPs panels on the 16' long trailer at SJCC.

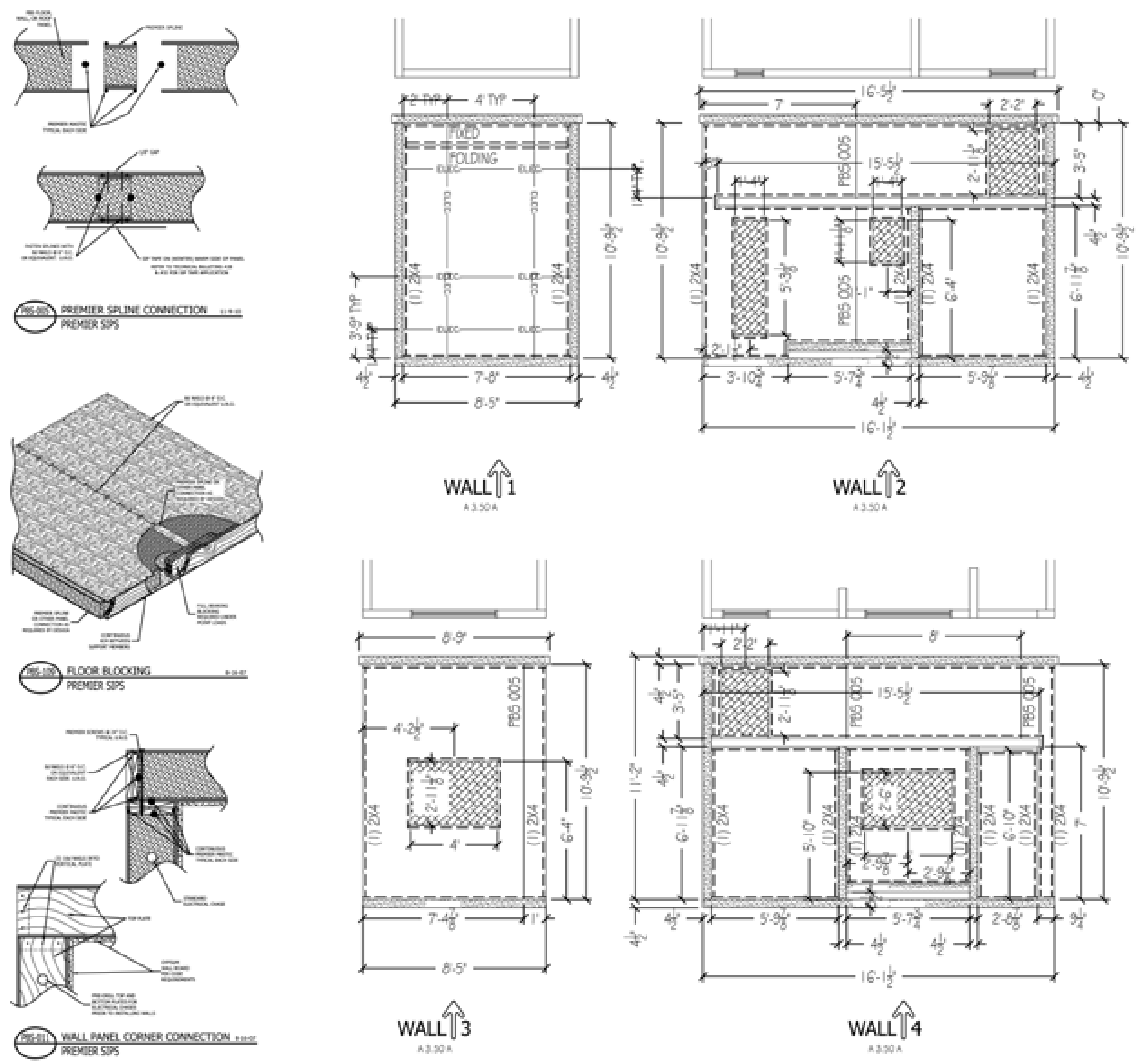
Students and Faculty burning the midnight oil at SJCC.

The completed MIKRA House at the SMUD Design Competition

KEY DESIGN FEATURES

- Structure built out of pre-fabricated 'structural in-sulated panels' (SIPs) to reduce construction waste, assembly time and provide superior insulation.
- 250 sf interior floor space with additional 155 sf remote controlled folding wall panels with canvas enclo- sures
- 945W solar panel array
- Hybrid 120Vac & 12Vdc electrical circuits
- 4.8kW power output at 50% Depth of Discharge (DOD)
- 800Ah battery bank
- 3000W inverter
- All-electric appliances - induction cook-top, refrig-erator, electric hot-water heater, LED lighting
- Custom built Raspberry Pi 3 home automation system with voice activation
- Cork exterior spray-on texture/waterproofing
- Converts to 4 bedrooms, sleeps up to 6
- Optional greywater & rain water recycling system

MIKRA shop drawings provided by Premier SIPs for fabrication and easy assembly.




Judging in
progress.
Do not enter

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- Art Elsea
- Dan Parent
- Matthew Welch
- Joyce Fukuman
- Kim Hoopingarner
- Jerry Kauffman
- Warren Krause
- Chris March
- Aaron Mayes
- Constantine Papachristopolous

ADMINISTRATION
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- Dr. Ingrid Thompson
- Dr. Moni Dickerson

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- Chris Blackmore
- Iraji Fouladi Chami
- David Coffman
- Markus Cruz
- Michael Dao
- Joseph Heady
- Adrian Keeley
- Hugo Legend
- Son Nguyen
- Tam Nguyen
- Armando Patanao
- Ray Turner
- Daniel Um
- Jorge Vazquez
- Carlos Villanueva

Special Tribute to:
Kieron Connelly, John Brandlund III, Dan Ramirez Jr.


T WRIGHT
BREUER
New York
GEHRY
ARCHITECTURE
ARCH
Subnature
JAPANESE PRINTS
GAUDI
CASE STUDY HOUSES
Scandinavian
Frank Lloyd Wright
ANSEL ADAMS

2.2 Jade House, Veteran Housing

Foothill College
Science and Learning Institute

The Jade House is designed for quick off-grid installation for temporary or accessory uses. It does not need a permanent foundation and can be installed on a ground plane that is sloping or not level. The Jade house comes in different sizes - small, medium, large. The 'small' version, pictured here, is 160 sf and suitable for single-occupancy with a ground floor and a loft sleeping option. It is built on a trailer frame for easy portability.

CONSTRUCTION

The Jade House can be delivered in approximately 4 -6 weeks depending on the level of custom design options. The structure is fabricated with SIPs (structural insulated panels) for superior insulation, lighter weight and reduced assembly time. An optional 'Smart Solar' glass wall offers automated natural lighting and power generation with integrated photo-voltaic blinds.

Partnerships with local educational institutions (Rancho Cielo, San Jose City College, UC Santa Cruz) allow students to learn critical job skills and reduce production costs.

UTILITIES

The integrated solar PV system allows for off-grid 'islanding' system or grid tied use. The power system is designed for net-zero energy operation. A solar thermal panel offers hot water for showering. Rain water storage is provided by a storage tank. Grey-water filtration is provided by a exterior 'constructed wetland' planter.
The combined toilet/shower saves space, minimizes plumbing and waterproofing materials. The toilet can be operated without a sewer system as a composting toilet (inquire about our user-management agreement) or if available, tied to a sewer system for longer term convenience.

COST

There are several customized options that can be provided for a wide range of budgets, depending on your needs and desired options - size, power needs, material choices. Please contact us for a detailed cost estimate.

COLLABORATORS

The Jade house was designed in collaboration with Tiffany Wise-West, Eco-shift and the Foothill College Science and Learning Instiutute

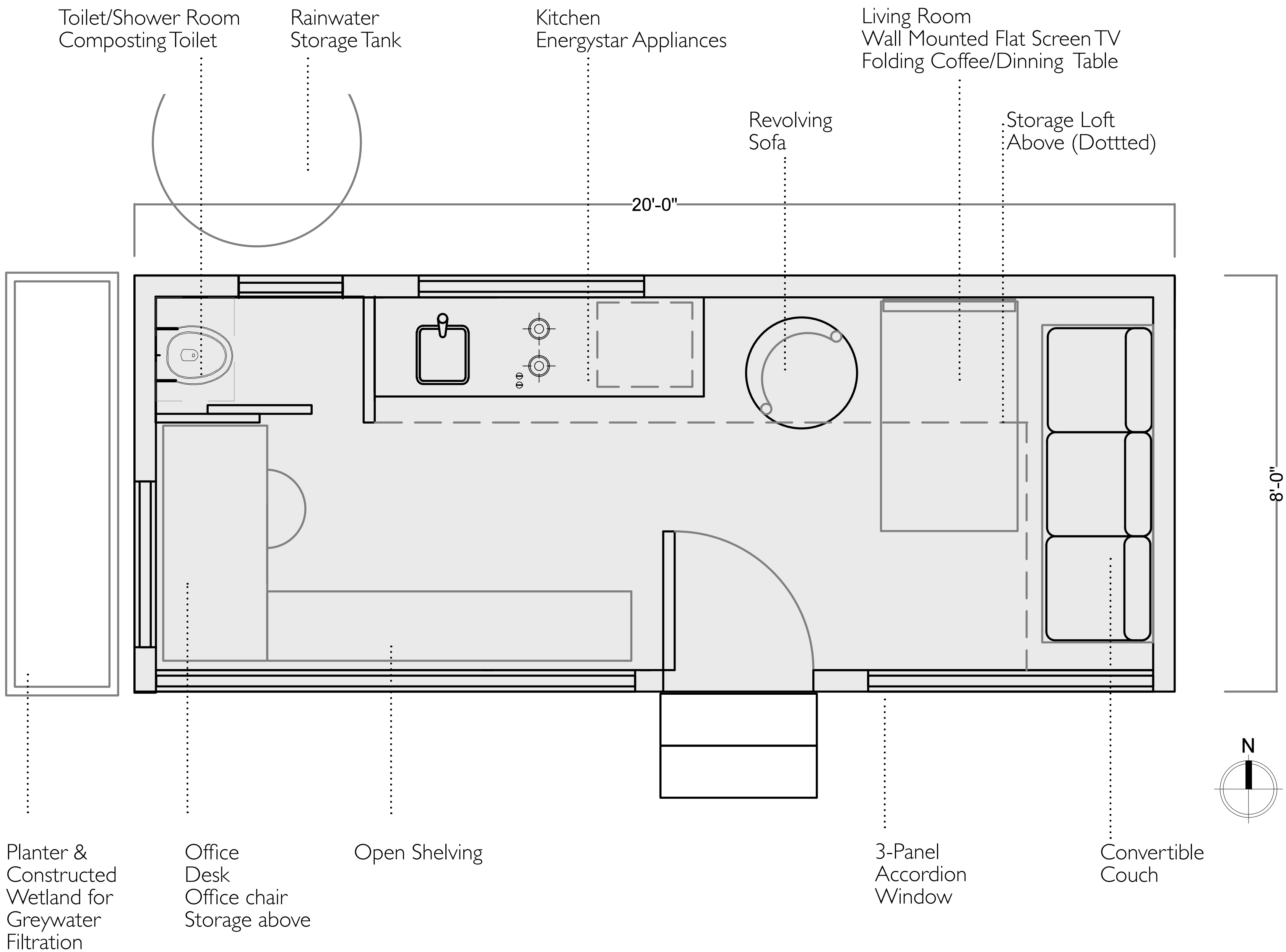
JADE HOUSE CONSTRUCTION

The Jade House Micro Dwellings are prefabricated at the construction and fabrication shop at educational construction facilities such as San Jose City College, UC Santa Cruz, Cabrillo College, Hartnell College, Rancho Cielo Construction Academy as well as local high schools.

Pre-fabrication allows for reduced construction time, reduced construction costs, less waste and increased accuracy as well as enhanced safety and comfort for the production team.

Involving a diverse local student production team gives at-risk youth as well as college/university students the opportunity to learn critical STEAM-related job skills and encourages pathways into local colleges and universities.

The Jade House with greywater filtration planter, rain water tank, roof mounted solar panels


Toilet/Shower Room
Composting Toilet
Rainwater
Storage Tank
Kitchen
Energystar Appliances
Living Room
Wall Mounted Flat Screen TV
Folding Coffee/Dinning Table
Revolving
Sofa
Storage Loft
Above (Dottted)
20'-0"
8'-0"
N
Planter &
Constructed
Wetland for
Greywater
Filtration
Office
Desk
Office chair
Storage above
Open Shelving
3-Panel
Accordion
Window
Convertible
Couch

PROJECT PARTICIPANTS

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Johnathan Flores
Ivy Chen
Madeline Kringel
Makena Savidge
Bailey Weiner
Emet Levy
Katie Stermer
Rachel Ruiz

2.3 UCSC μ = MicroPod @Tiny House Design Lab

Tiny House Design Lab thanks
UC Santa Cruz Rachel Carson College
Ronnie Lipschutz & Kevin Bell
UCSC Arboretum
Sustainable Systems Research Foudation (SSRF)
Ecologic Design Lab

The UCSC μ = Multi-use Micro Pod Tiny House lays emphasis on flexibility and portability as a key feature for sustainable design. It is portable in order to be easily installed in a variety of locations. It's light weight structure allow it to be transported by a common passenger car. It is designed in panels for (dis)assembly. Its design for multiple uses allows it to adapt to current needs.

The project development from concept to completion allows students to experience a variety of integrated project-based hands on training in architecture, engineering, applied sciences, construction and electronics as well as soft skills in team collaboration and project management.

- Mobile Research Lab
- Job Site Utility & Office Trailer
- Renewable Power Source
- Transitional Housing
- Secure Storage
- Sound & Media Booth
- Educational Micro-Electronics Display
- Mobile Greenhouse

KEY DESIGN FEATURES

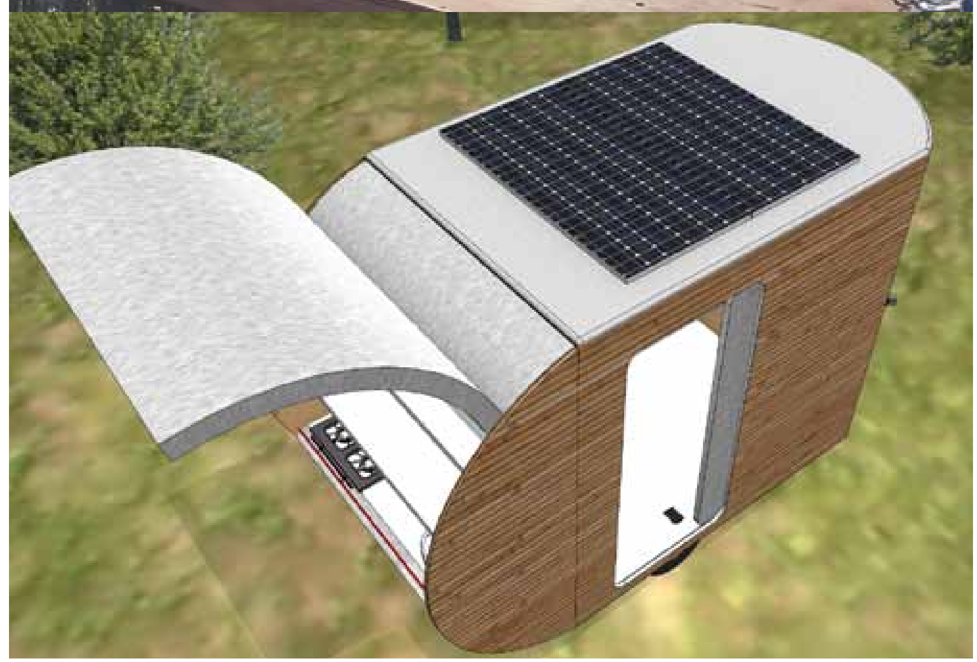
- Portable
- Built on an 4' x 8' utility trailer ($370.00)
- Light weight transported with standard passenger car
- Interior transforms into work space, lounge space & sleeping area
- Net-zero renewable energy system
- Floor framing extends a max width of 8'
- Comfortable interior head room of 7 feet
- Max allowable trailer capacity (Max GVR) 1980 lbs.
- Use recycled / reclaimed / donated materials
- Water storage
- Bamboo siding grown, harvested, and processed at UCSC
- Modular design for (dis)assembly

POWER SYSTEM

- Three Solarworld, 315W, Sunmodule Pro-Series XL Panels
- WSS Battery Bank UPG 200ah @ 24VDC 4,800 watt hours
- Midnite Solar Classic MPPT Charge Controller 150
- Magnum Energy MMS1012G Inverter

SMART SYSTEMS INTEGRATION

- Central Controller (such as Arduino and RaspberryPi) remote control and access
- Renewable energy system monitoring
- Home security monitoring
- Air quality monitoring (for IAQ and field research)
- Automated shading
- Automated lighting
- Ultra-sonic distance monitoring
- Water level and solar thermal monitoring



PROJECT BASED LEARNING

The MicroPod project serves as an applied science hands on, project based teaching tool. Giving students the opportunity to practice and apply the theoretical concepts they have acquired. In the process of practice a diverse set of practical skills are learned to reach project completion.

DIVERSE PROJECT TASKS

- Project Management

Training in web-based project management and collaboration tool (such as Basecamp) to manage to-dos, files, messages, schedules, and milestones. Establish team roles based on student interests and encourage team-work and integral design methods.

- Architectural Design

Iterative design process to get from concept to completion in team environment using research and design skills.

- Sketching and Drafting

Communicate visual ideas and spacial relationships in 2-dimensional sketches and drafting.

- Physical scale modeling

3-dimensional design using scale modeling to simulate form, structure, material choices and functions.

- 3-dimensional modeling

Virtual modeling, solar analysis, site analysis, dimensioning

- Structural Engineering

Foundations, wall framing, shear walls, environmental forces

- Construction Management

Budgeting, green building materials sourcing and application.

- Renewable Energy Integration

System sizing, design and installation.

- Integrated Micro Systems

Smart home automation using micro controllers to regulate temperature, lighting, indoor air quality, power consumption, remote monitoring, irrigation, sound, ventilation, security system, etc.

2.4 Pocket House, Hartnell College

The Pocket House is a new innovative model for sustainable living. CONS 150 students will design build and test a compact housing unit that is fully functional with regard to the necessities of everyday life.

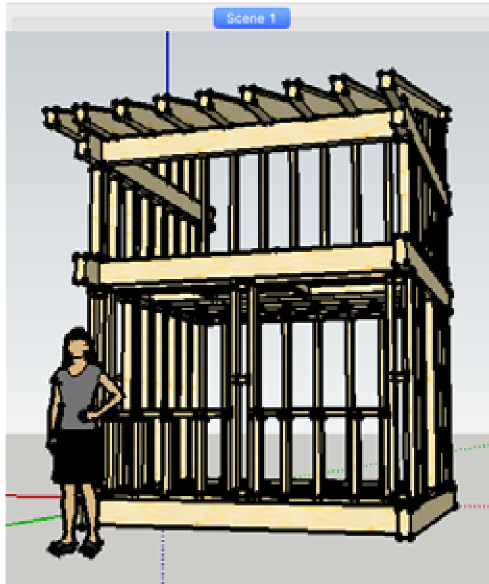
Some of the Project goals include

- Design a portable low-cost living unit with a minimal footprint of 10' x 10'
- Maximize the energy efficiency of the integrated building systems and reduce its operating costs
- Design and install self sufficient and clean, renewable energy systems so the unit can be deployed in any location and function without depending on a centralized utility grid.
- Provide an instructional case study of sustainable design and construction to be displayed at learning institutions in the Central California Region.
- Allow for maximum flexibility by making the unit portable and transformable relative to the seasons and types of uses.
- Provide a tangible life-size display of the type of skills being taught and products being developed at the Hartnell College East Alisal Campus and the Hartnell College Center for Sustainable Design and Construction
- Pioneer a cross-disciplinary cross-institutional project based teaching module for replication at other learning institutions. Currently the Pocket House project is involving interns from local high schools, interns and instructors from Hartnell College, Interior Design students from Monterey Peninsula College, graduate students from University of California Santa Cruz, Baskin School of Engineering.
- Provide a platform to interact with industry partners on a 'real-world' design and construction challenge (industry partners include Hayward Lumber, Hayward Foundation, Don Chapin, Applied Solar, EcoLogic Design Lab).
- Display the use of Green Building Materials and Methods

The results of the Pocket House design and construction process were on display at the Intership Symposium August 24, 2013

Hartnell College Pocket House from concept to design, engineering and construction

POCKET HOUSE
TEAM MEMBERS
Jessica Landa
Nikka Johnson
Andres Aranda
Melissa Ramos
Maureen Morla
Mike Thomas
John Anderson
Thomas Rettenwender



HARTNELL
COLLEGE

Hartnell College Pocket House - designed for portability with 4 x 12 outriggers and steel brackets.

2.5 THIMBY - TINY HOUSE in my BACKYARD, UC Berkeley

We are Tiny House in My Backyard (THIMBY), an interdisciplinary team of UC Berkeley graduate and undergraduate students that worked together to design and build an affordable, off-grid, 100% solar-powered "tiny" house at the Richmond Field Station in Richmond, CA. In October 2016, we transported the house to Sacramento to compete in the Sacramento Municipal Utility District's (SMUD) 2016 Tiny House Competition, where we took 2nd place overall and won specific awards for home life, water conservation, sustainability, and craftsmanship.

The house generates its own electricity, and is small enough to fit in the unused portions of urban lots. Cities around the world face the challenge of housing a growing population while the size, cost and carbon footprint of homes continue to rise. THIMBY is a 170 sq. ft. one bedroom, one bathroom home that is designed to serve two residents and aims to demonstrate the compatibility of affordability and sustainability.

This project represented an opportunity for students from diverse departments to learn about sustainable design principles through hands-on experience in all phases of development, from design to construction to performance evaluation. The house is compact, but provides a comfortable and inviting home environment, with a focus on energy and water efficiency. Now that the SMUD competition has passed, our team is continuing to test the home's systems at the Richmond Field Station. THIMBY's permanent resting place is still unknown, but there are many exciting possibilities. THIMBY could be the first home in a community of carbon neutral housing, or serve as a residence for a park caretaker and partner along the Richmond Greenway.

THIMBY @ BERKELEY

Berkeley UNIVERSITY OF CALIFORNIA

THIMBY HOUSE - PANELIZED CONSTRUCTION METHODS, HEALTHY BUILDING MATERIALS AND LOTS OF SMILES !

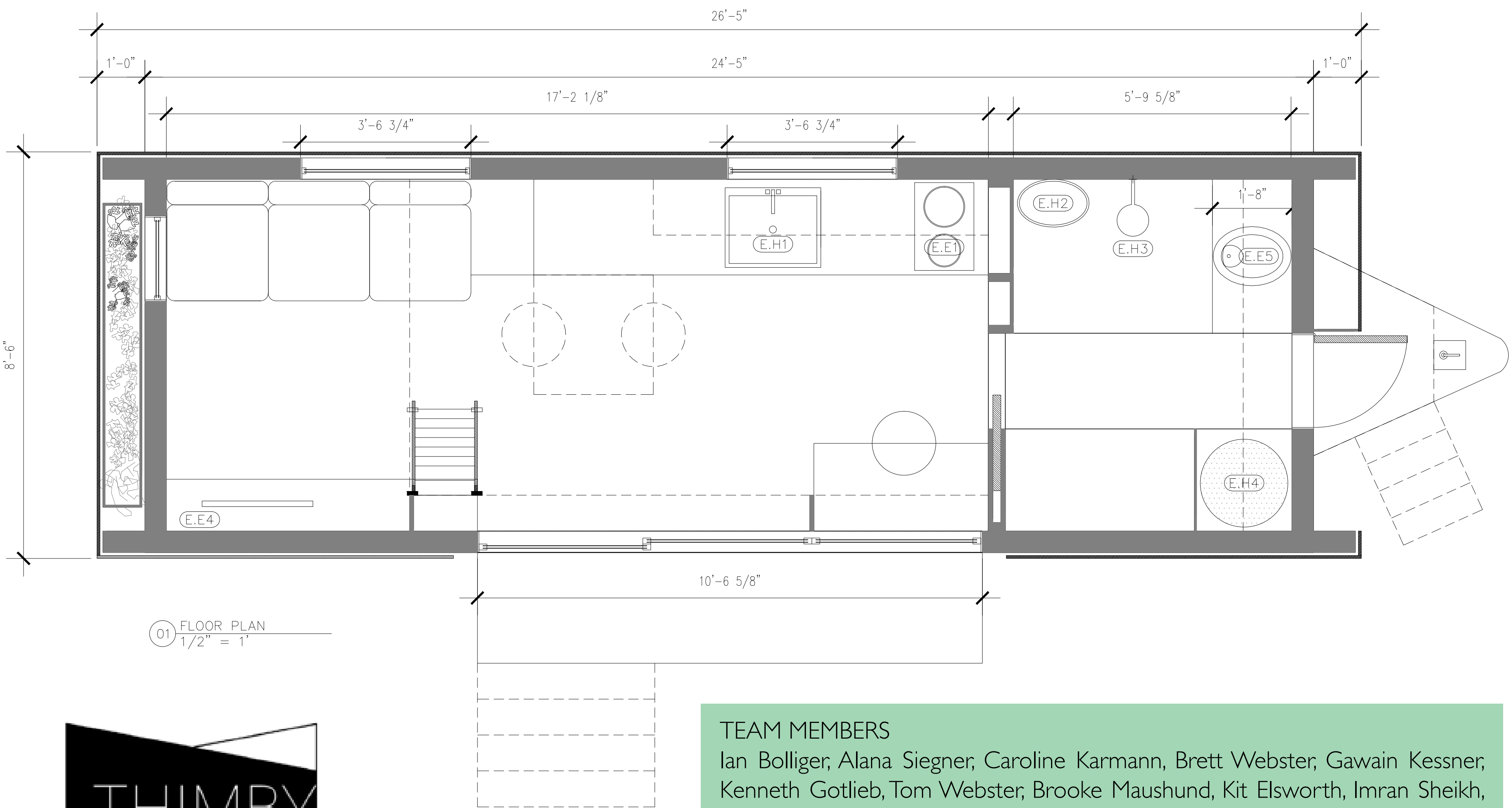
THIMBY, a 170-ft², one-bedroom, one-bathroom house, was designed to meet the needs of a couple including a grad student, living in the Bay Area. The specific end location will depend on accessing land available for off-grid tiny houses, and could include an urban park, urban farm caretaker housing, or integration within a pilot community of off-grid eco-homes. Featuring carbon-negative cork insulation and reclaimed cedar siding, THIMBY was built to reflect the environmental sustainability values of its end users.

The house is powered by a 2.3 kW PV array, generating electricity that can be stored in the unit's 6.4 kWh Li-Ion battery. THIMBY recycles greywater through a vertical flow "living wall" filtration system combined with an activated carbon filter and UV disinfection light for later non-potable use in the shower or for irrigation. Water and space heating are powered by an air-to-water heat pump that utilizes CO2 as a low-Greenhouse Warming Potential (GWP) refrigerant. Rainwater collection and human waste composting also allow THIMBY to cost-effectively minimize its life cycle emissions, demonstrating the compatibility of sustainability and affordability objectives.

While serving as a functional home for a graduate student and partner, THIMBY will also be used as an educational model for other green building projects taken on by student groups and researchers at UC Berkeley. THIMBY will integrate a Home Energy Management and online water quality monitoring system to ensure reliability and performance of all energy and water system components.

THIMBY @ BERKELEY

THIMBY House - Floorplan built on a 24 foot long trailer



TEAM MEMBERS

Ian Bolliger, Alana Siegner, Caroline Karmann, Brett Webster, Gawain Kessner, Kenneth Gotlieb, Tom Webster, Brooke Maushund, Kit Elsworth, Imran Sheikh, Sara Tepfer Oriya Cohen, Emily Woods


TINY HOUSE in my
BACKYARD
Sustainable, affordable, tiny.

2.6 The rEvolve House, Santa Clara University

Santa Clara University undergraduate students have come together over the past two years to build a tiny house filled with big amenities and comfort. The 238 sq. ft tiny house is a fraction of the size of a traditional house, yet it is constructed to meet our audience's needs in a sustainable way.

We have designed the rEvolve House as a short term, low cost housing solution for Operation Freedom Paws, a non-profit organization that prepares veterans to train their own service dogs. The tiny house provides the first step in the journey of empowering veterans to evolve their independence and is a safe haven for them to acclimate and begin training their dogs prior to returning to their respective homes.

The architecture of the home is designed around a coastal contemporary theme that will provide a calming and accommodating environment for any disability that the veterans may face. All aspects of the home are dog friendly in order to enhance the quality of life to both the veteran and his or her service dog.

The house features a bedroom with a Murphy bed and a full sized kitchen that incorporates a seating area and fold out table. The home will also contain a 35 sq. ft wet bathroom with a dry-flush toilet that will eliminate the use of a black water system. The walls will be constructed with Structural Insulated Panels, which will make our house stronger and more energy efficient than a traditional stick framed home. The rEvolve House also features an accessible roof deck that provides an expanded seating area for six.

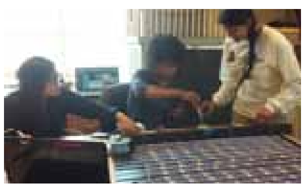
In order to support an off-grid lifestyle, the house is powered entirely by eight 330 Watt Sunmodule solar panels. The house stores its energy using saltwater batteries, the only batteries in the world to be Cradle to Cradle certified. In order to improve the home's solar efficiency by 30%, the house's trailer will be connected to a Colossun solar tracking ring allowing the entire house to revolve as the sun moves across the sky.

http://revolvehouse.com/about

Faculty:
Tim Hight, Ph.D, James Reites, S.J.
TEAM MEMBERS
Don Bollard, Jonathan Bors,
Jun Chang, Gabriel Christ, Thomas Chun, Kaileen Cruden,
Jack Dinkelspiel, Brianna Eremita
Elena Fromer, Joyce Fung, JJ Galvin, George Giannos, Marcus Grassi, Anna Harris, Mike Heffernan, AJ Hood, Kara Horwald, Olivia Hsieh, James LeClercq , Matt LoGrasso, Taylor Mau, Nico Metais, Nathan Metzger, Samantha Morehead, Martin Prado, Sam Suri , Emma West , Alexander Polatnick.


SIMPSON
Strong-Tie

3.0 Zero-Net Energy Systems



3.1 Zero-Net Energy Systems Design Basics

The Zero-net Tiny House format offers a useful case study for 'zero net energy systems design. Tiny houses, by definition are portable and must achieve a level of self-sufficiency. Producing their own power is a first step in achieving this autonomy. A well designed solar PV system can be used to produce as much or more power than is needed for comfortable living. This is the basic concept behind 'zero net energy'.

With recent movements to pro-actively achieve greater energy efficiency through implementing energy efficiency through state-wide energy efficiency standards the consumer is forced to achieve a level of energy efficiency with any new construction or remodel. This reduces dependence on the electrical grid saving costs in energy production and helps avoid capacity issues such as the so called 'duck curve'.

Achieving greater energy efficiency can be costly and a burden on the building industry. Government rebates have helped alleviate this burden. Energy efficiency measures pay for themselves after a few years but require a larger initial investment.

In a well equipped tiny home half the budget can go towards the systems cost. An important first step in system design is an energy use analysis. It can be a challenge to predict how the home will be used and how it will adapt over the years. Here are a few initial steps to figure out an energy budget that will help the designer determine capacity needs. By economizing our use we can reduce systems cost and ensure that our renewable energy system is properly sized. If properly sized we can ensure the same comforts of a grid tied system. And every watt not used (negawatt) is a watt that does not need to be produced, processed or stored.

Step-by-Step Guide to designing your zero-net power system.

1. **Estimate power demand** by making a list of all estimated power users (equipment, tools, audio, visual, lighting, pumps, outlets, etc.)
2. Use a 'flow' , 'network' or **system diagram** to understand all the components needed and how they are related.
3. Evaluate the **space requirements** of your system. Estimate how the equipment will fit in a limited space. Consider all surfaces - total roof surface & exterior wall surfaces. Consider multi-use 'stacking of functions' like awnings, drawers, slanting surfaces, glass surfaces, blinds, etc.
4. Contact a **solar supplier** to help you quantify the make and model of the system components - panels, batteries, inverter, charge controller, mounting hardware, etc.
5. Design and install **the Electrical system**. Decide where switches, outlets, lighting, pumps, circuits from power source, etc. Will be placed in relation to the floorplan and volume available. Consult with a Licensed Electrician to make sure you have the electrical wiring set-up correctly.
6. Install the solar energy system with its components and mounting hardware. Solar panel mounting systems attach to the roof or wall surface, a frame or a free standing structure like blinds or louvers. Power supplied by the panels is regulated by a charge controller. The energy is then stored in batteries. The batteries will supply consistent power to the dwelling. You can add an inverter to supply AC power for standard domestic appliances. Batteries, charge controllers, inverter, and all circuit breakers need to be in a dry and weatherproof area. This equipment is usually stored in a ventilated utility closet.
7. For additional 'smart' home functions design and install a CPU system like Arduino or RaspberryPi . This CPU panel needs to be easily removable for transport and servicing. A modular assembly system can allow for future additions and alterations. A power supply needs to be provided. If it is easy to disconnect the panel you can remove it for servicing.

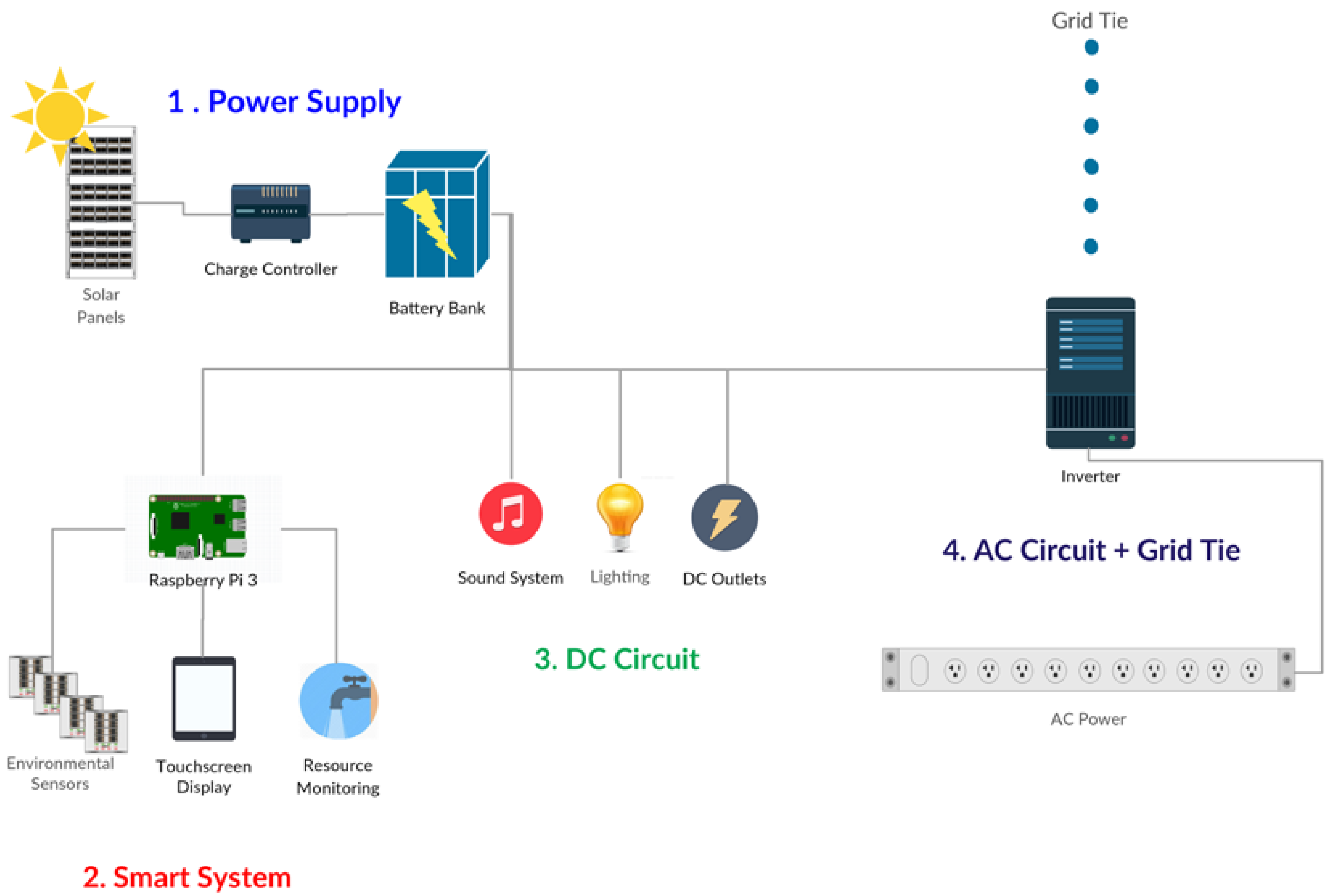
SAMPLE ENERGY EFFICIENCY STUDY AND POWER BUDGET ESTIMATION.

Appliance	Qty.	Volts	Run Watts	Hours /Day	Days /Week	W-hours /Day
refrigerator	1	117	1350	0.4	7	540
stove top	1	120	1200	2	7	2400
toaster oven	1	120	1150	1	7	1150
Bathroom Light	2		3.56	1	7	7
range hood	1	120	192	2	7	384
monitor (TV)	1	120	150	4	7	600
laptop	1	150	150	4	7	600
cell phone	2	5	8	3	7	48
eletric winch	4	120	500	0.5	4	571
fans (bathroom)	1	120	100	1	7	100
water pump	2	120	200	1	7	400
sound	1	120	60	1	7	60
Room Light	2	120	120	2	7	480
Kitchen Light	1	120	120	2	7	240
blender	1	220	300	0.1	7	30
vacuum						0
						0
					Total Daily Average Watt-hrs	7611

	Incandescent	CFL	LED
Approximate cost per bulb	$1	$2	$8 or less
Average lifespan in hrs.	1,200	8,000	25,000
Watts used	60W	14W	10W
No. of bulbs needed for 25,000 hours of use	21	3	1
Total purchase price of bulbs over 23 years	$21	$6	$8
Total cost of electricity used (25,000 hours at $0.12 per kWh)	$180	$42	$30
Total operational cost over 23 years	$201	$48	$38
Savings (%) vs Incandescent		**76.1%**	**81.1%**

3.2 UCSC MicroPod Systems Design

BASIC SYSTEM DIAGRAM FOR A HYBRID AC/DC POWER SYSTEM WITH INTEGRATED RASPBERRYPI CENTRAL PROCCESSING UNIT (CPU).



DESCRIPTION OF SYSTEM COMPONENTS

1. Power Supply

945 Watt photovoltaic system (3panels)
- up to 6.6 kWh per day
- as low as 3.5 kWh per day

200 amp-hour battery bank
- 4.8 kWh storage
- Charge controller to prevent damage to batteries from overcharging

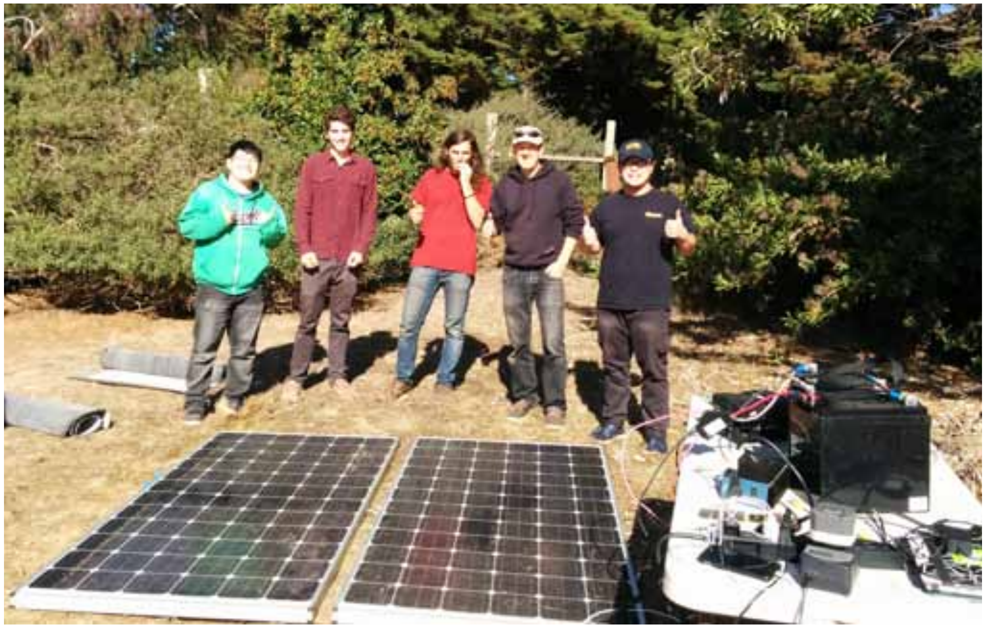
2. Smart System

Raspberry Pi 3
- Programmable microprocessor
- Monitor the effectiveness of the structure and track resources
- Automate other components : lighting, shading, sound system, etc.

Environmental Sensors
- Modules compatible with the Pi thet collect data
- Sensors for temperature and humidity
- Air quality (Dust Sensor, Gas Sensor, hCHO sensor)
- Can be used to monitor and regulate the comfort of the structure or for environmental testing and field research

Resource Monitoring
- Pi moules can be hookrd up to the power system to track energy use and battery levels
- Ultrasonic distance-measuring sensors can monitor the watr tank level

Touchscreen Display
- Prents the data in an elegant user-friendly interface
- Teaches occupants how to effectively use the structure, makes sustainable living simpler



3. DC Circuit

Efinciency Boost

-Panels produce DC power, and many appliance use DC (LED lights, speakers, phones/laptops)

-A DC circuit avoids conversion back and forth from AC, saving energy

4. AC Circuit + Grid Tie

Inverter

-Converts DC power to AC power

-Allows support for AC appliances

-Allow for connection to the AC grid

SAMPLE SOLAR PANEL SPECIFICATION SHEET

Sunmodule
SW 315 XL MONO (33mm frame)

SOLARWORLD REAL VALUE

TUV Power controlled: Lowest measuring tolerance in industry

Every component is tested to meet 3 times IEC requirements

Designed to withstand heavy accumulations of snow and ice

Sunmodule Plus: Positive performance tolerance

25-year linear performance warranty and 10-year product warranty

Glass with anti-reflective coating

World-class quality
Fully-automated production lines and seamless monitoring of the process and material ensure the quality that the company sets as its benchmark for its sites worldwide.

SolarWorld Plus-Sorting
Plus-Sorting guarantees highest system efficiency. SolarWorld only delivers modules that have greater than or equal to the nameplate rated power.

25-year linear performance guarantee and extension of product warranty to 10 years
SolarWorld guarantees a maximum performance digression of 0.7% p.a. in the course of 25 years, a significant added value compared to the two-phase warranties common in the industry, along with our industry-first 10-year product warranty.*

*in accordance with the applicable SolarWorld Limited Warranty at purchase.
www.solarworld.com/warranty

UL 1703

solarworld.com

Sunmodule
SW 315 XL MONO (33mm frame)

SOLARWORLD REAL VALUE

PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)*

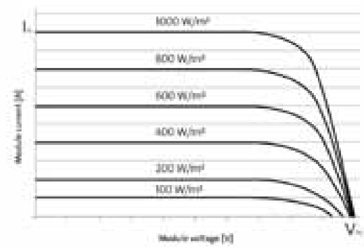
Maximum power	P_{max}	315 Wp
Open circuit voltage	V_{oc}	45.6 V
Maximum power point voltage	V_{mpp}	36.5 V
Short circuit current	I_{sc}	9.35 A
Maximum power point current	I_{mpp}	8.71 A
Module efficiency	η_m	15.79 %

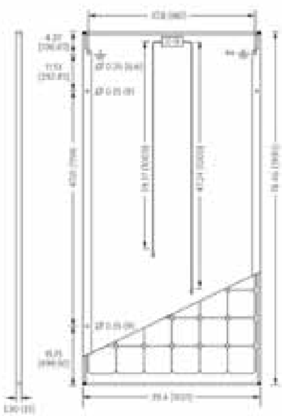
*STC: 1000 W/m², 25°C, AM 1.5

1) Measuring tolerance (P_{max}) traceable to TUV Rheinland: +/- 2% (TUV Power Controlled)

THERMAL CHARACTERISTICS

NOCT	46 °C
TC I_{sc}	0.042 %/°C
TC V_{oc}	-0.304 %/°C
TC P_{mpp}	-0.43 %/°C
Operating temperature	-40°C to 85°C





PERFORMANCE AT 800 W/m², NOCT, AM 1.5

Maximum power	P_{max}	240.9 Wp
Open circuit voltage	V_{oc}	39.8 V
Maximum power point voltage	V_{mpp}	33.6 V
Short circuit current	I_{sc}	7.77 A
Maximum power point current	I_{mpp}	7.18 A

Minor reduction in efficiency under partial load conditions at 25°C: at 200 W/m², 100% (+/-2%) of the STC efficiency (1000 W/m²) is achieved.

COMPONENT MATERIALS

Cells per module	72
Cell type	Mono crystalline
Cell dimensions	6.17 in x 6.17 in (156.75 x 156.75 mm)
Front	Tempered glass (EN 12150)
Frame	Clear anodized aluminum
Weight	47.6 lbs (21.6 kg)

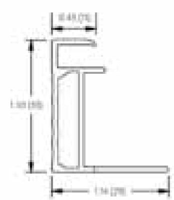
SYSTEM INTEGRATION PARAMETERS

Maximum system voltage SC II / NEC		1000 V
Maximum reverse current		25 A
Number of bypass diodes		3
*Design Loads**	*Two rail system*	113 psf downward 64 psf upward
*Design Loads**	*Edge mounting*	178 psf downward 21 psf upward

*Please refer to the Sunmodule installation instructions for the details associated with these load cases.

ADDITIONAL DATA

Power sorting¹	-0 Wp / +5 Wp
J-Box	IP65
Module leads	PV wire per UL4703 with H4 connectors
Module type (UL 1703)	1
Glass	Low iron tempered with ARC

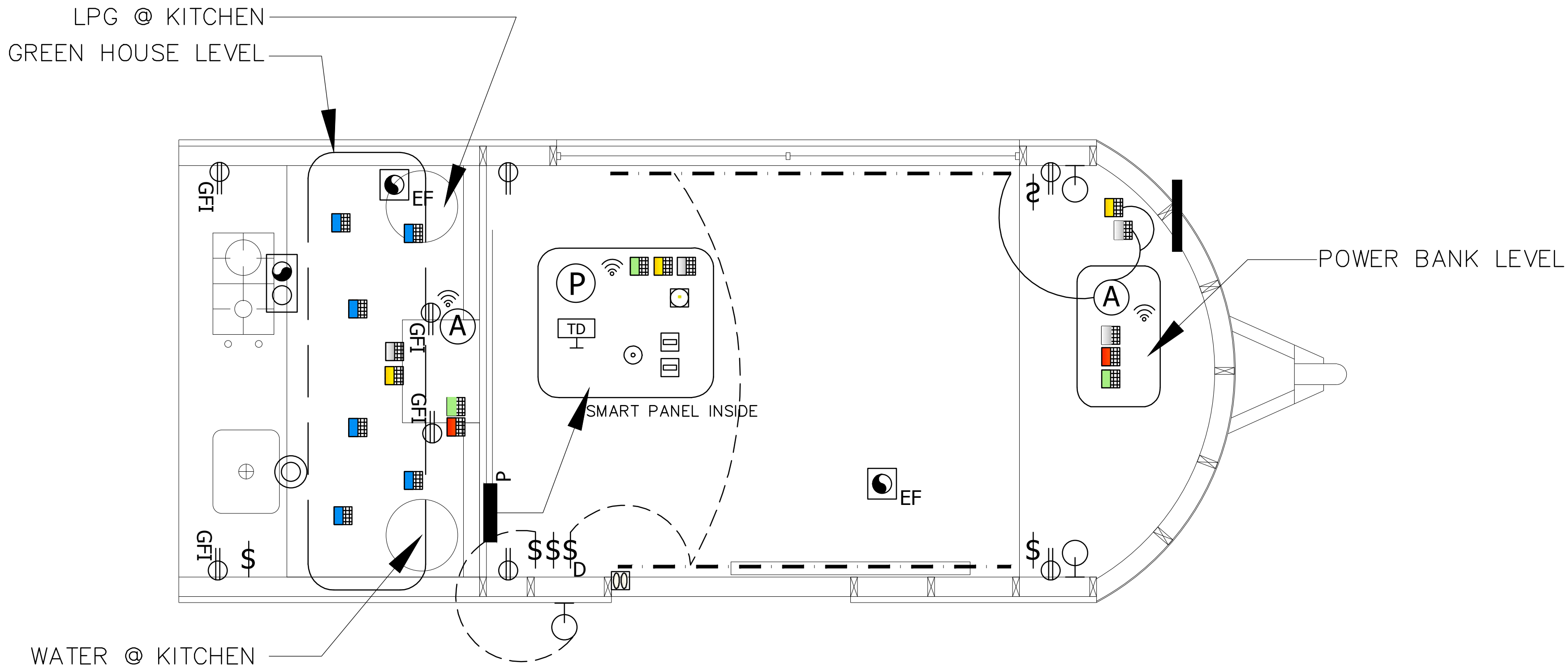


- Compatible with both "Top-Down" and "Bottom" mounting methods
- Grounding Locations:
  - 4 locations along the length of the module in the extended flange.

All units provided are imperial. SI units provided in parentheses.
SolarWorld AC reserves the right to make specification changes without notice.

SW-01-7105US-1 04-2015

UCSC MICROPOD ELECTRICAL & MICROSYSTEMS PLAN



ELECTRICAL SYMBOLS

- Raspberry Pi
- Arduino
- DHT 22 (temp/humidity)
- Photoresistor
- Moisture Sensor
- Flame Sensor
- MQ2 Gas Sensor
- 3.3V–5V TTL
- MCP 3008 ADC

- Reed Switch
- Transmitter/Receiver
- 12VDC Outlet
- 5VDC USB Outlet
- Alarm Buzzer
- TD Touchscreen Display
- Peristaltic Pump
- Solenoid valve
- SMART PANEL

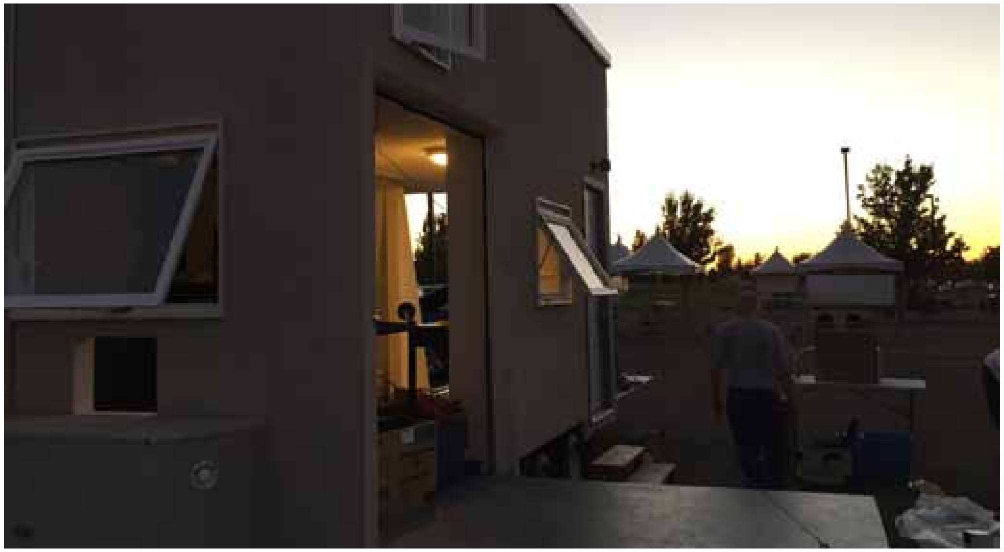
- $ SINGLE POLE SWITCH
- $ DIMMER SWITCH
- 110V. DUPLEX OUTLET
- 110V. GRND FAULT INTERRUPTOR
- 110V. WEATHER PROOF
- LOW VOLTAGE FIX. – WALL MOUNT
- LED STRIP LIGHTING
- FAN / LIGHT COMBINATION
- EXHAUST FAN

3.3 MIKRA House Systems Design, San Jose City College

Motorized winch to lower the folding panels (above) with remote control from Raspberry Pi control system built into the wall near the entry (below).

Key Design Features

- Structure built out of pre-fabricated 'structural insulated panels' (SIPs) to reduce weight, waste, assembly time and provide superior insulation.
- 250 Ft^2 floor space with additional 150 ft^2 remote controlled folding wall panels with canvas enclosures
- 945W solar panel array
- Hybrid 120 -VAC & 12 -VDC electrical circuits
- 4.8kW power output at 50% DOD
- 800Ah battery bank`
- 3000W inverter
- All electric appliances - induction cook-top, refrigerator, electric hot water heater, led lighting
- Raspberry Pi 3 home automation system with voice activation
- Cork exterior spray-on texture/waterproofing
- Comfortably sleeps up to 5 people
- Greywater & rain water recycling system.



SAMPLE DC ONLY SOLAR SYSTEM QUOTE PROVIDED BY WHOLESALE SOLAR, JUNE 2015

Wholesale Solar, Inc
POB 124
Mount Shasta CA 96067

Quote Number: 122317
Date: 6/22/2015
Salesperson: Wil

Toll Free: 800-472-1142
Local Phone: 530-926-2900
Fax: 530-926-1162
www.wholesalesolar.com

BILLING
Gerald W. Bernstein, City College of
City College of San Francisco
1400 Evans Avenue
San Francisco CA 94124

Split *Residential with Liftgate*

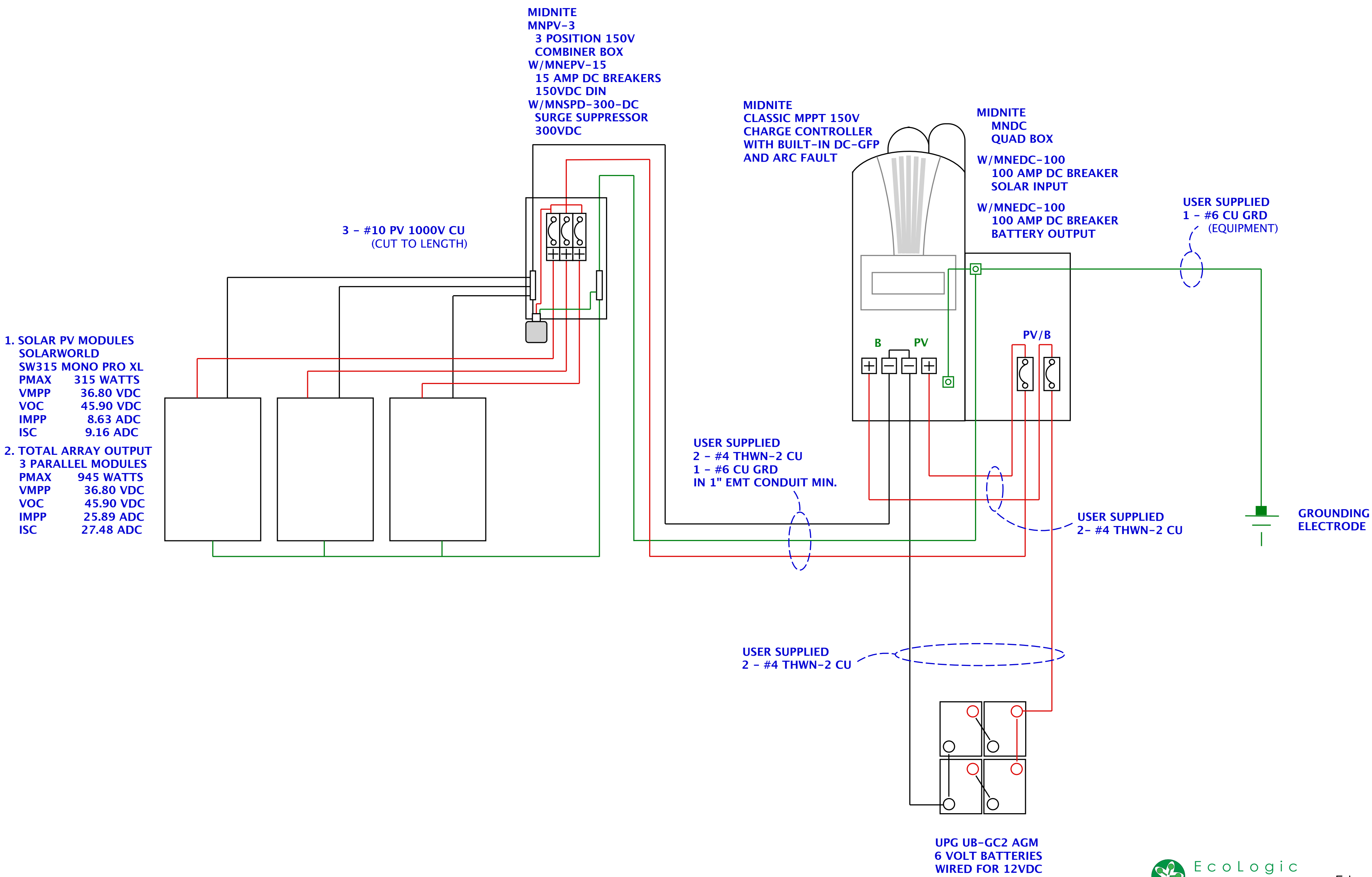
SHIPPING
San Jose City College
123 Placeholder Pl.
San Jose CA 95101
GBernste@ccsf.edu

Quantity	Part	Description	Price	Extension
3	1922279	Solarworld, 315W, Sunmodule Pro-Series XL, Silver Mono, SW315, 46mm	$335.00	$1,005.00
3	9994165	4 Star Solar MC4 10 AWG-PV Wire - 50' cable extension	$45.00	$135.00
3	8500322	Midnite Breaker DC DIN MNEPV-15 15 amp 150VDC DIN, 13mm	$12.50	$37.50
1	9930041	Midnite Surge Suppressor MNSPD-300-DC	$85.00	$85.00
1	8910239	MidNite MNPV-3, 3 Position Combiner Box	$72.00	$72.00
1	3900141	Midnite Solar Classic MPPT Charge Controller 150	$607.00	$607.00
1	9991000	Midnite Breaker Box MNEDC Quad for panel mount DC breakers	$50.00	$50.00
2	8941125	Midnite Breaker DC Panel Mount MNEDC-100 amp 150VDC 3/4"	$25.00	$50.00
1	1898565	WSS Battery Bank UPG 400aH @ 12VDC 4,800 watt hours (4)	$870.00	$870.00
4	9996646	*UPG UB-GC2 200 aH 6V AGM Battery*		
2	9850022	*4 Star Solar 2/0 - 12" UL Cable, Battery Interconnect (white)*		
1	9850012	*4 Star Solar 2/0 - 18" UL Cable, Battery Interconnect (white)*		
1	9851012	*4 Star Solar 2/0 - 18" UL Cable, Battery Interconnect (red)*		
1	9000013	Service - Shipping & Handling	$358.34	$358.34
1	9000178	Discount - **Massive Moving Sale - Ends June 30th**	-$358.34	-$358.34

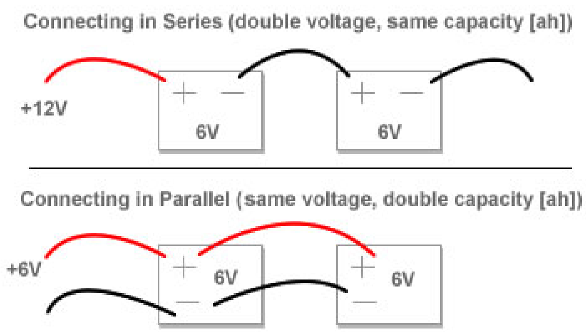
Sub Total:	$2,911.50
Tax:	$218.36
Quote Total:	$3,129.86
Savings:	$358.34

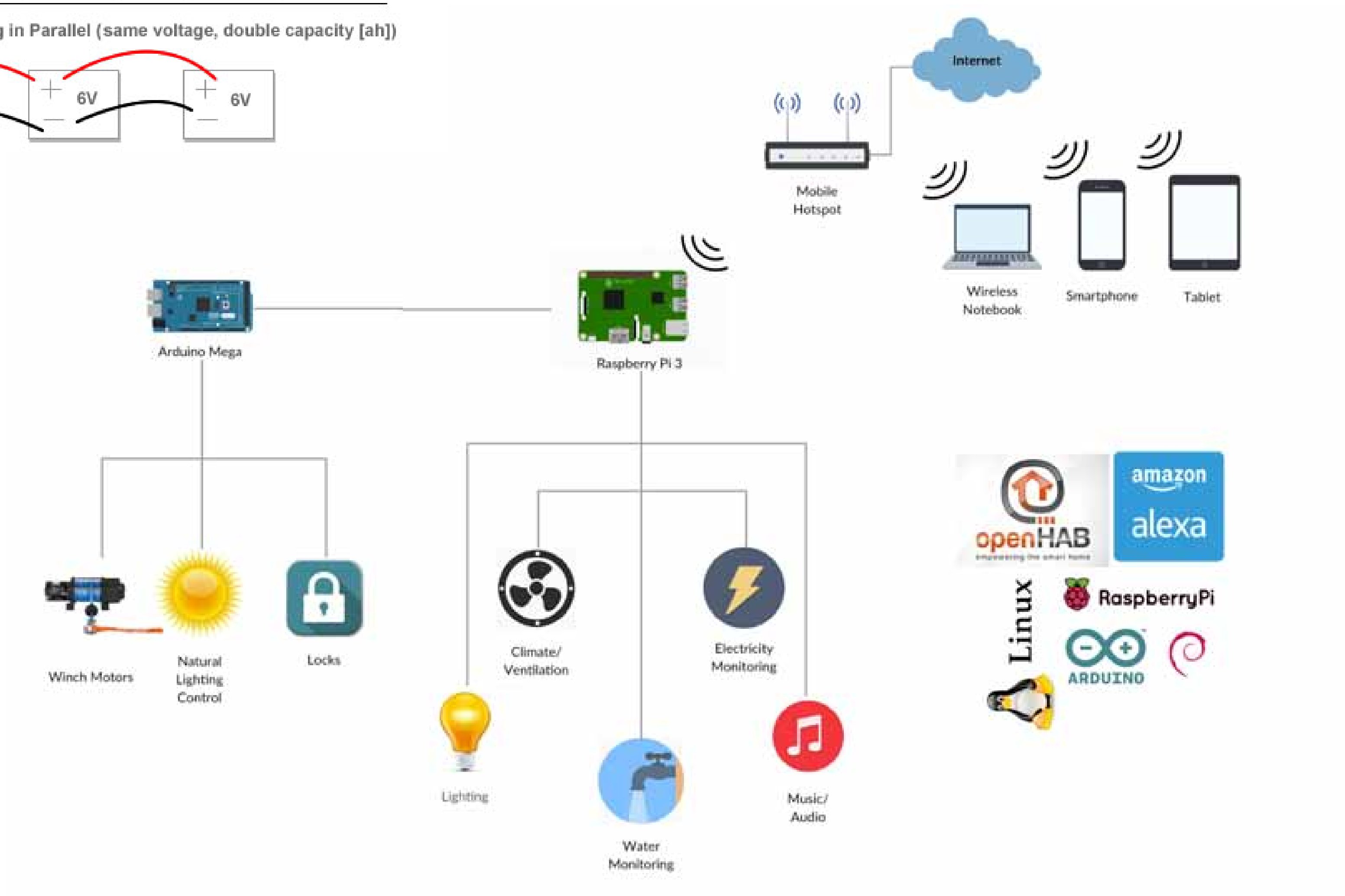
This quote is a DC only system, requires payment by check or bank transfer.

SOLAR SYSTEM NETWORK DESIGN PROVIDED BY WHOLESALE SOLAR



POWER SYSTEMS DESIGN DIAGRAMS





3.3 Pocket House Power Systems

Building solar PV blinds by glueing and welding together solar cells for the Hartnell College Pocket House

A low-tech solar thermal panel built using pex tubing in a black enclosure with a transparent cover creating a 'greenhouse effect'.

Assembly of the Solar PV blinds and transportation of the pocket house using a crane attached to the beams with custom designed brackets.

3.4 THIMBY Systems Design, UC Berkeley

THIMBY @ BERKELEY

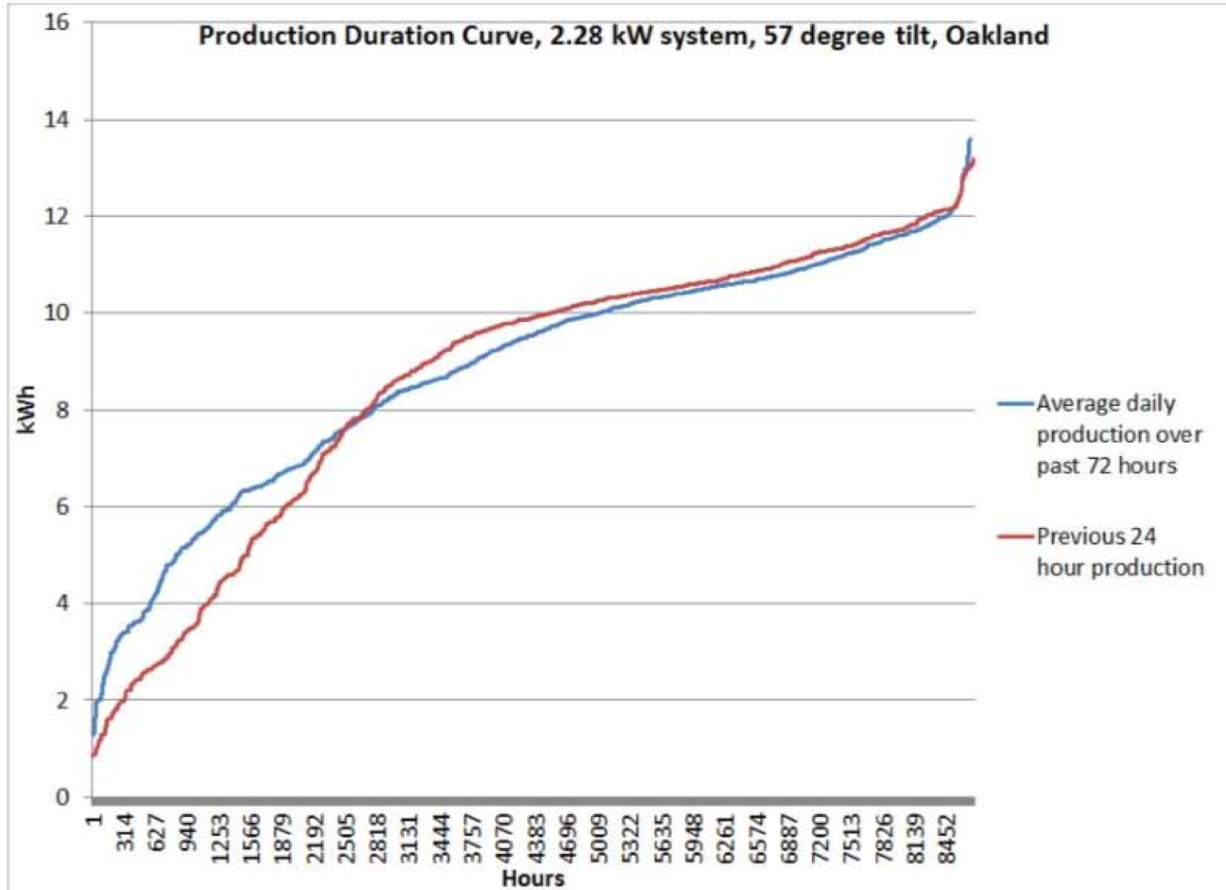
Berkeley UNIVERSITY OF CALIFORNIA

ENERGY PRODUCTION & STORAGE

Our design goal for THIMBY was to create a comfortable space that could operate entirely off-grid for an entire year if needed. Through the design process we realized that delivering enough energy to meet all loads with absolute certainty over every hour of the year would come at a prohibitively high cost. We therefore relaxed our goal to provide complete comfort for all but 5 days per year. On those days, we decided that occupants could sacrifice some comfort, shower elsewhere, or grid connect.

PV PRODUCTION

We found that the PV production at our location was the biggest constraint to meeting all of our demands. Rather than over-sizing the PV beyond the roof area, we chose to use energy more efficiently for our space and water heating needs. The plot below shows how much energy our PV system would produce, on average, over the previous 24 hours. Since we have battery storage, the last 24 hours of production was not necessarily the best metric of energy that would be available to serve loads. Instead, we calculated what the average daily production would be over the past 3 days, as shown in the blue line below. Doing so highlights that



there are some, though limited, time periods with consistent low production. If we assume that total loads would be around 4 kWh per day, there would be ~600 hours when the past production was insufficient to meet demand. We also find that there are many hours when we would expect large surpluses in energy production, which means that THIMBY could serve as a large net producer of electricity over the course of the year.

Our main concern, given the scarce energy resource that we have, was that we would not have enough energy for space and water heating (the biggest energy demands in the house). Thankfully, the plot below shows that the days of low kWh production from PV are not necessarily the coldest. On this plot it's not necessarily the days on the left that are worrisome.

A home energy management system (HEMS) is under development to control THIMBY's heat pump, radiant floor, and energy recovery ventilator (ERV). The system will sense indoor and outdoor air temperature, mean radiant temperature, (heated) floor temperature, refrigerator/freezer temperature, PV generation rate, and battery state of charge. Incorporating week-ahead weather forecasts, we will employ Model Predictive Control (MPC) with a Dynamic Program (DP) to optimize thermal comfort given constraints on forecast generation and outdoor temperature, battery size and charge/discharge rate, fridge/freezer temperature, pump speeds, and hot water temperature.

A prototype of the control algorithm for this system, as well as a report and poster on the preliminary results, is available on GitHub at h ttps://github.com/bolliger32/thimby-hems.git. The open-source software is licensed with Apache License 2.0 and was developed as the final project for Civil and Environmental Engineering (CEE) 295: Energy Systems and Control. A full implementation of the algorithm will not be available for the competition as work is ongoing. Project groups in two courses this semester (Electrical Engineering and Computer Science CEE 186: Designing Cyber Physical Systems and CEE 271: Sensors and Signal Interpretation) are working with three THIMBY members to further develop the algorithm and incorporate sensing and actuating hardware to realize the goal of a full implementation.

HVAC STRATEGY

Heating and cooling strategies

<u>Passive systems:</u>

- Passive solar heat gains due to the orientations and window location

<u>Active systems:</u>

- The thermal storage is our source of heat for both domestic hot water and heating
- A hydronic radiant floor distributes heat in the main space.
- The thermal storage is located nearby the bathroom and we plan on taking advantage of the losses of the tank to heat that space.
- Energy recovery ventilator that will allow the house to be well ventilated in winter while not loosing too much heat for ventilation purpose

Cooling systems

<u>Passive systems:</u>

- Natural ventilation
- Phase change materials: this material melts at 77°F (25°C). At this temperature a lot of energy can be absorbed by the ceiling. This will help to keep the house at more comfortable temperature during hot days. It acts like added thermal mass around the melting temperature.

<u>Active systems:</u>

- Ceiling fan: will allow to expand the thermal comfort zone through the effect of elevated

VENTILATION

THIMBY includes 2 ventilation devices that will ensure proper air change in the space:

- An energy recovery ventilator located in the main space
- A bathroom fan to remove humidity from the shower

ELECTRICAL STORAGE

We chose to install a 7kWh Tesla Powerwall battery, which should be sufficient for meeting our electrical energy storage needs. The plot below shows what the battery state of charge would be over the course of the year, assuming a constant load of 167 watts (4kWh per day). Since the main worry is having enough energy for space heating, we also plot, on the same axis, the hourly outside temperature. The areas of concern are highlighted in red, when the battery runs out completely. There are about 100 hours when the battery would be out, but we see that these are not on very cold days. Multiple days of cloud cover also probably means that temperatures are not terribly cold.

THERMAL STORAGE

Perhaps the most innovative part of our energy system design is the use of thermal energy storage, in the form of a large (for a tiny house) hot water tank. A 42 gallon hot water tank with water at 149F is equivalent to 10 kWh of additional energy storage if the incoming water is 50F. We use this tank to produce hot water during hours of PV production, which means that we can save the electrical energy in the battery for higher value end uses. When PV production is low, it also means that we have some additional energy stored in the form of hot water which allows us to serve our space and water heating needs for several days longer than if we relied on an on demand system.

HOME ENERGY MANAGEMENT SYSTEM

A home energy management system (HEMS) is under development to control THIMBY's heat pump, radiant floor, and energy recovery ventilator (ERV). The system will sense indoor and outdoor air temperature, mean radiant temperature, (heated) floor temperature, refrigerator/freezer temperature, PV generation rate, and battery state of charge. Incorporating week-ahead weather forecasts, we will employ Model Predictive Control (MPC) with a Dynamic

Program (DP) to optimize thermal comfort given constraints on forecast generation and outdoor temperature, battery size and charge/discharge rate, fridge/freezer temperature, pump speeds, and hot water temperature.

A prototype of the control algorithm for this system, as well as a report and poster on the preliminary results, is available on GitHub at h ttps://github.com/bolliger32/thimby-hems.git. The open-source software is licensed with Apache License 2.0 and was developed as the final project for Civil and Environmental Engineering (CEE) 295: Energy Systems and Control. A full implementation of the algorithm will not be available for the competition as work is ongoing. Project groups in two courses this semester (Electrical Engineering and Computer Science CEE 186: Designing Cyber Physical Systems and CEE 271: Sensors and Signal Interpretation) are working with three THIMBY members to further devel-opphe algorithm and incorporate sensing and actuating hardware to realize the goal of a full implementation.

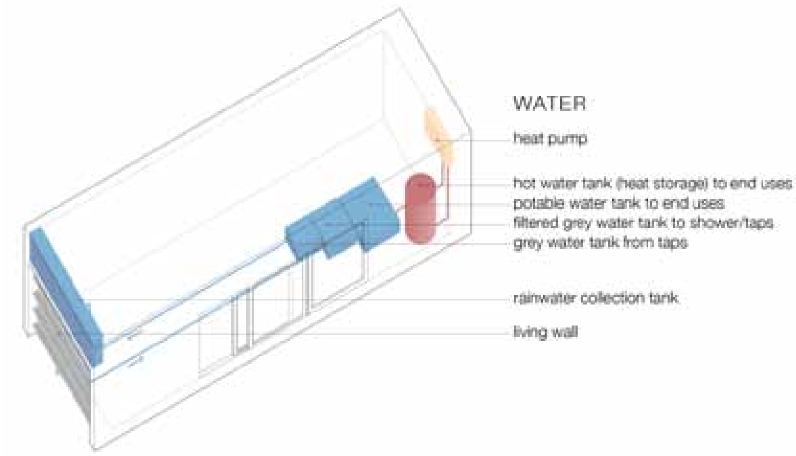
SAVING WATER

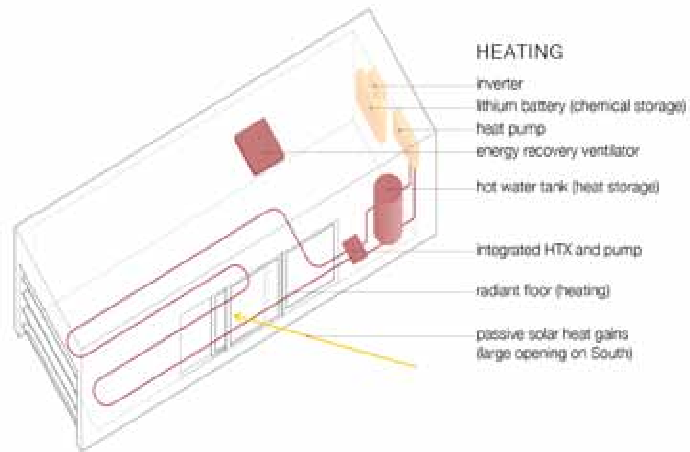
-The waterless compostable toilet eliminates one of the largest in-home residential uses of potable water: toilet flushing. Modern toilets can achieve efficiencies of 1.6 gpf (gallons per flush), but older toilets can use up to 7 gpf. Our composting toilet has a urine-diverting toilet seat, so that urine can be captured, stored, and reused for high quality agricultural fertilizer (see AmmPhoTek reference document in Plumbing Systems documentation). This creates a waste-to-resource opportunity that reconnects city residents with the food system by diverting urine from the waste stream and using the Nitrogen and Phosphorous present in urine as a valuable on-farm input.

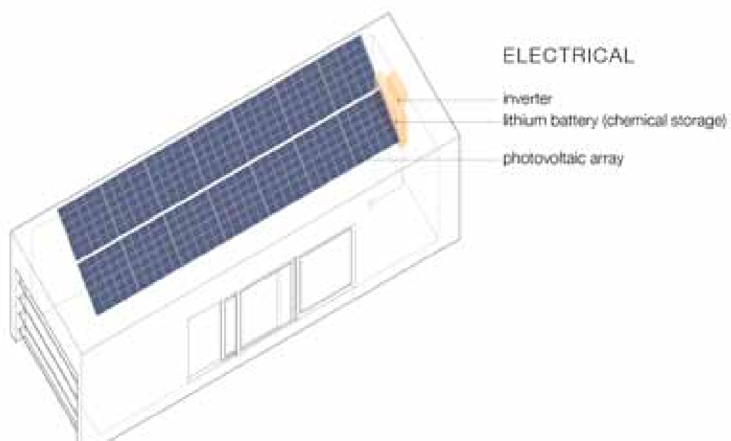
- The showerhead we are using is a low-flow, 1.5 gpm High Sierra showerhead that minimizes water use from showers compared to average American shower flow rate of 2.1 gpm.

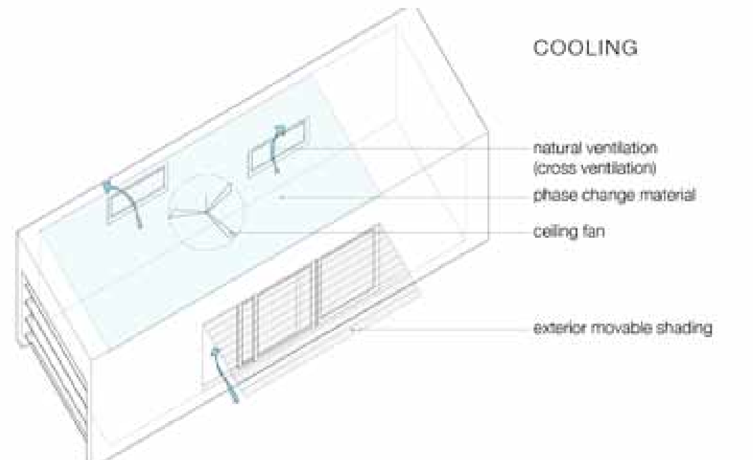
4.3.2. Collecting and recycling water

All greywater from sinks and shower will be collected and piped to the 40 gallon greywater tank, after passing through filter screens and a grease interceptor (in the case of the kitchen sink). The greywater will then be pumped to the "living wall" of 2 planter boxes, designed as a vertical-flow stratified bed wetland treatment system. Greywater will infiltrate via unsaturated flow and receive filtration through layers of mulch, coarse sand/soil, and finer sand. The plants growing out of the planter boxes promote aeration through their roots and provide locations for microbial communities to form, functioning as contaminant removal for the water passing through. Filtered greywater will then run through an in-line activated carbon filter, and into the filtered greywater tank (20g) with a UV disinfection light mounted to the ceiling to eliminate any remaining pathogens. This system, designed in consultation with professional and academic biosystems engineers, will allow the filtered greywater to be reused within the house for non-drinking uses. Water quality tests, forthcoming, will verify the safety of this filtered greywater for reuse in hand washing and showering, in addition to code-compliant greywater reuse options of subsurface irrigation and clothes washing. The mission behind the greywater filtration and in-house reuse is to tailor water use to water quality, maintaining public health standards while demonstrating innovation in water-saving residential systems.

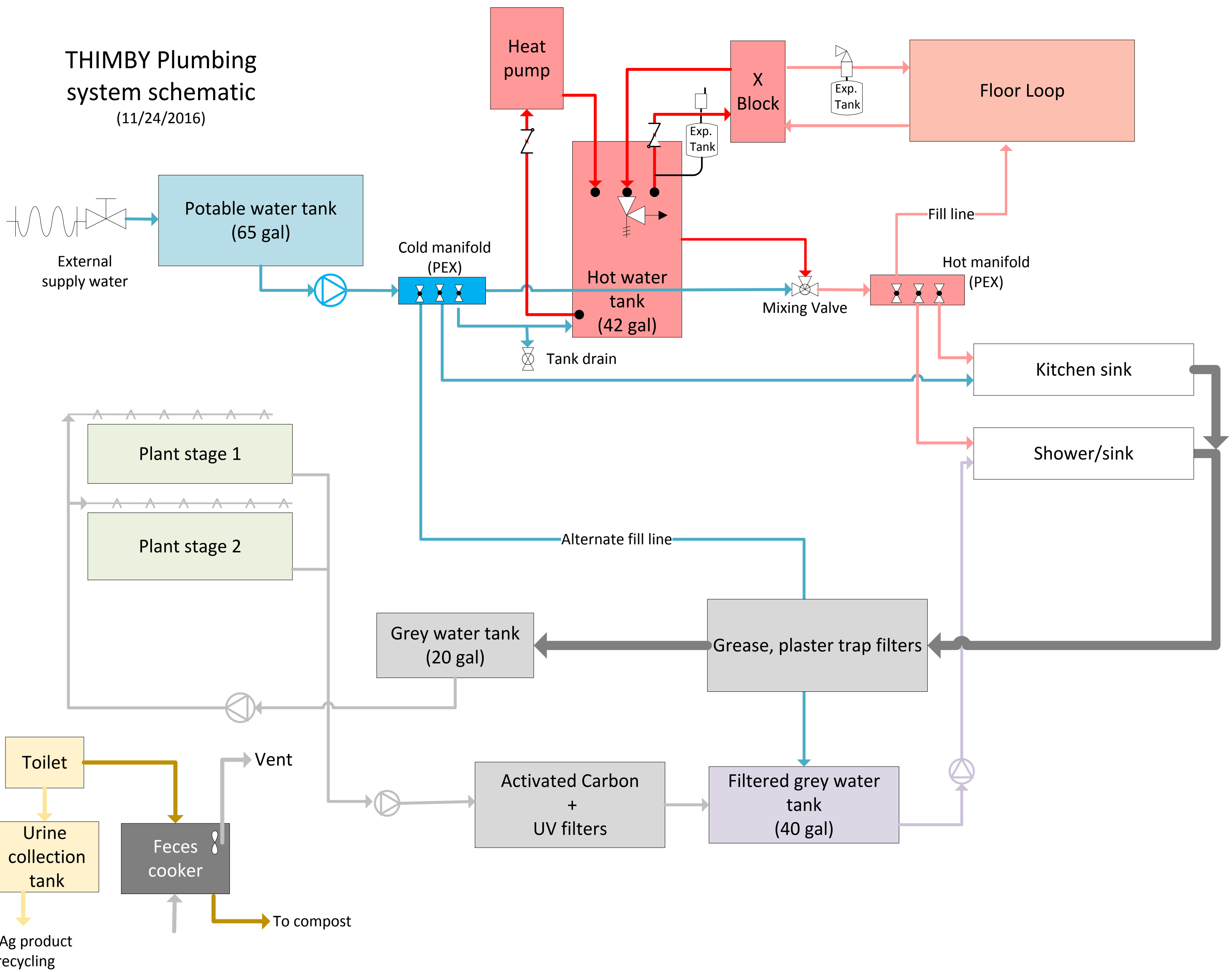








3D Models showing integrated systems



Berkeley
UNIVERSITY OF CALIFORNIA

GEOMETRY AND ORIENTATIONS

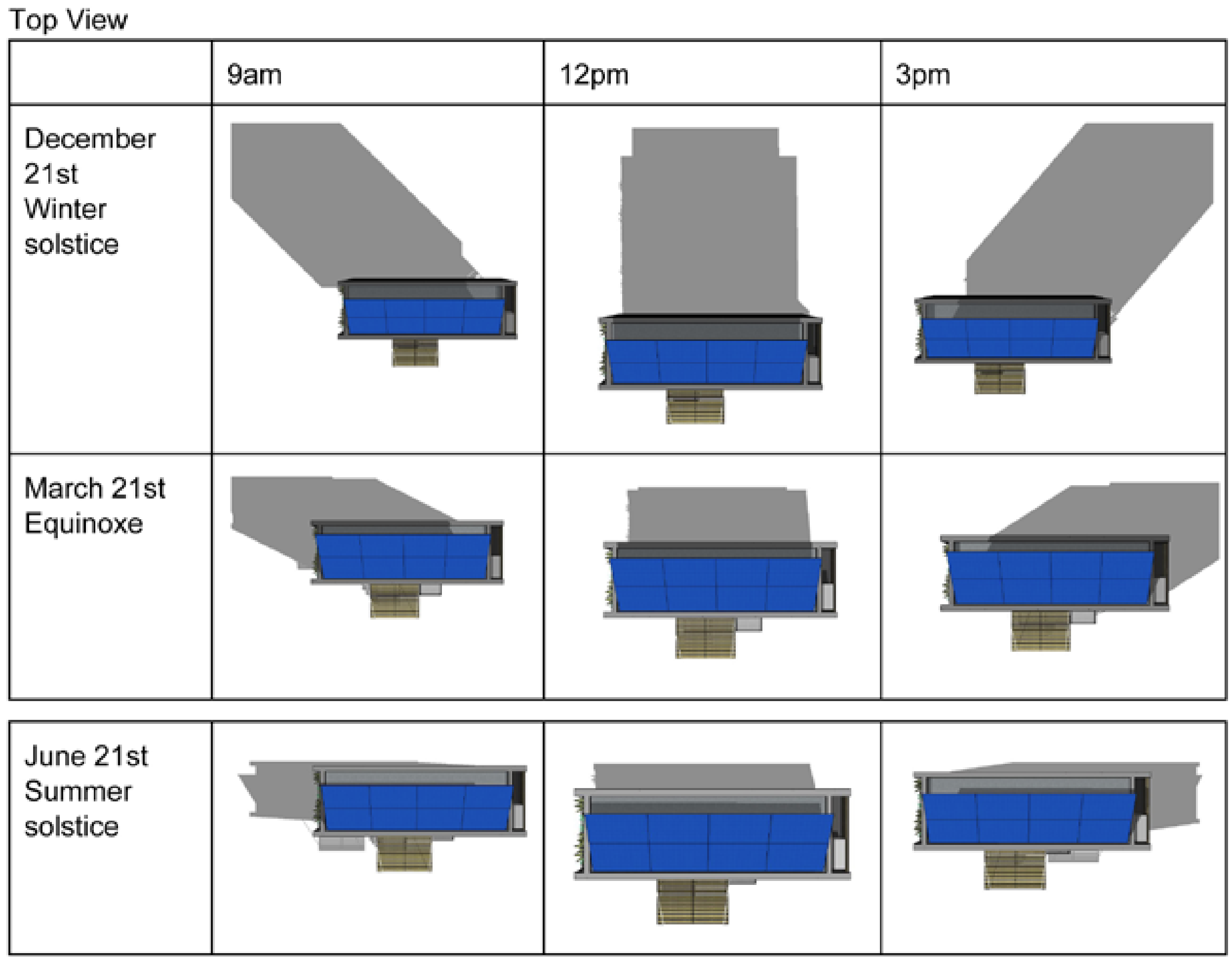
The geometry is given by the trailer (8' x 24' rectangle). Due to space constraints, we are going to occupy that whole surface. Because THIMBY is on wheels, it may be optimistic to define a unique orientation for the house. Yet, as we are off-grid, suggesting an orientation may help reaching a little more solar energy that can be extremely valuable.

As we are in the North hemisphere (Richmond, 38ºN, 122ºW), having the main facade of THIMBY face South has multiple advantages: it will allow significant passive solar heat gains in Winter due to the low Sun angle. With an appropriate solar shading strategy (overhang), the higher Summer can be blocked.

This orientation will also offer good opportunities for PV production (fundamental source of energy).

The series of image below show the sun angles for THIMBY located in the East Bay.

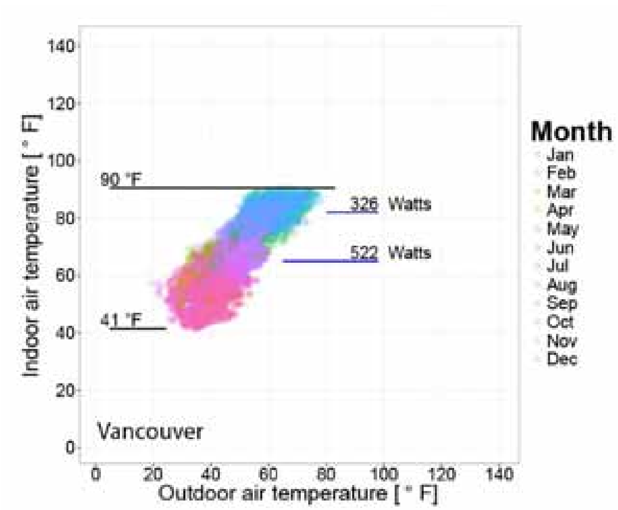
We chose to focus on the Equinox, Summer and Winter solstice which represent the average and more extreme days of the year. We conducted our analysis for 9am, 12pm and 3pm.

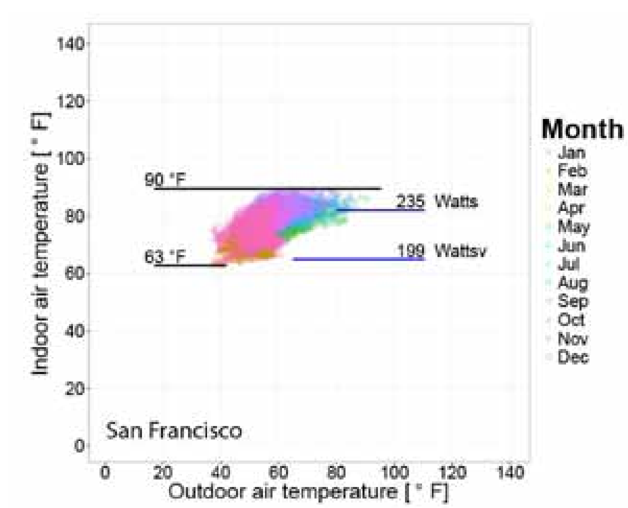


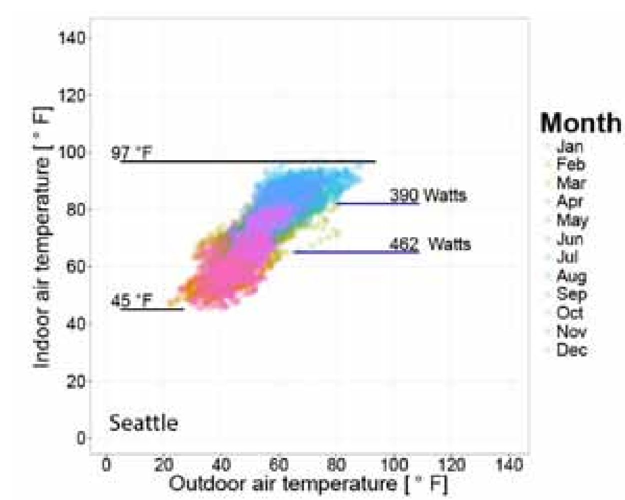
We can see that using a overhang on the South provides appropriate shading in Summer while it allows the Sun to enter in Winter and late Fall. For all days and hours simulated, this orientations offers a privileged orientations for inclined PV on the roof.

Energy plus

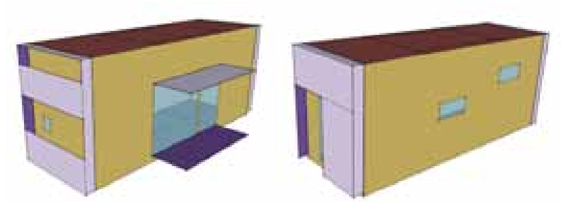
Visualization of the energy building model developed with EnergyPlus.





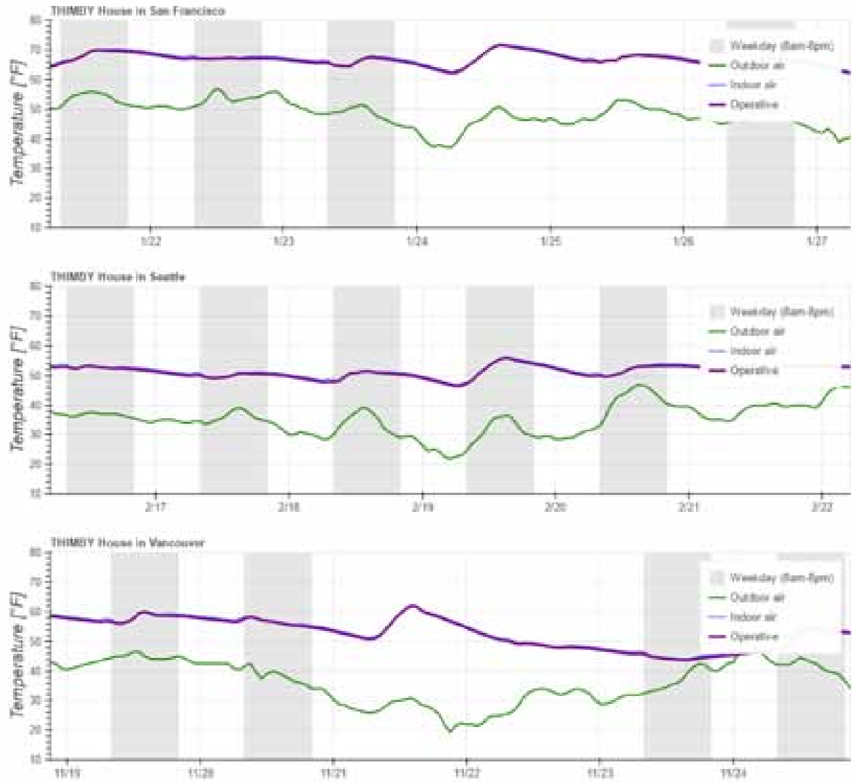


We modeled THIMBY using the simulation program 'EnergyPlus'. We chose this simulation as it is one of the most capable building simulation tools available today (able to account for dynamic behaviors).

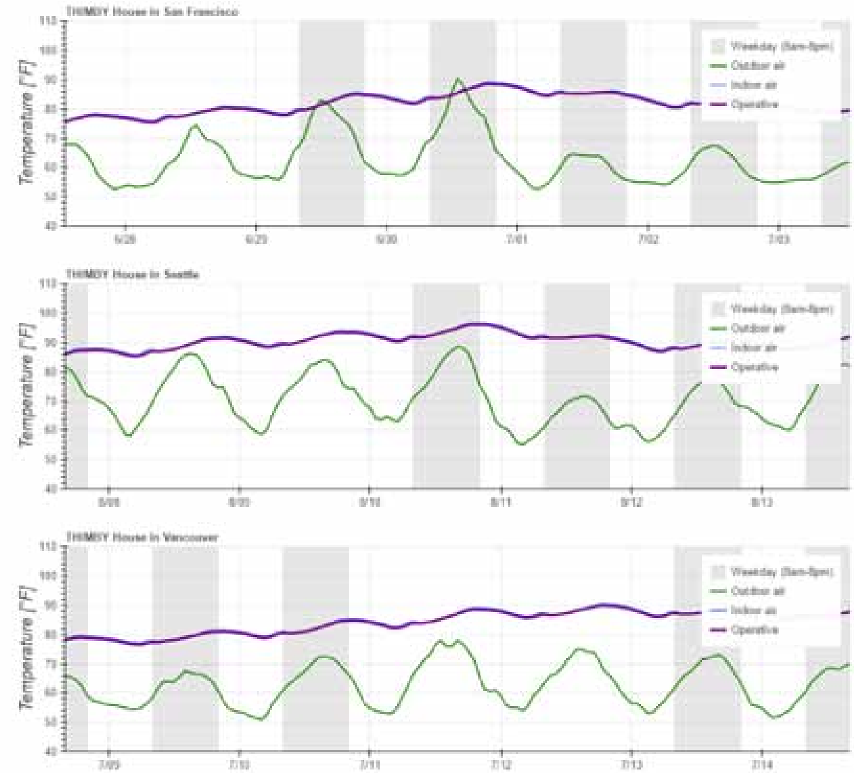


The two images above represent the Southwest (left) and Northeast (right) perspective of the energy model for THIMBY. We simulated the model in three different locations: 1) San Francisco, CA; 2) Seattle, WA; 3) Vancouver, BC, Canada, to represent a traveling THIMBY home along the upper west coast. We used the model to analyze worst case scenarios in which we chose the coldest and warmest day without a heating and cooling system to determine indoor temperatures THIMBY would experience in these situations. Then we used the energy model to determine the peak capacities needed for heating and cooling to maintain indoor temperature between 65 °F and 82 °F for the coldest and warmest day.

The graphs show above the Indoor Air Temperature (IAT) vs. Outdoor Air Temperature (IAT) from an annual energy simulation for the 3 cities of interest: San Francisco, Seattle and Vancouver. They also call out the maximum and minimum indoor temperatures that THIMBY would experience for the climate of a specific city without the use of HVAC system. Then, we used the thermal energy model to find out what is the peak capacity needed for a cooling and heating system to maintain indoor temperatures within 65 °F and 82 °F. This provides a rough estimate to size the THIMBY heating system accordingly.



Indoor thermal comfort in Winter without an HVAC system
- Plot for the coldest day in each of the cities' weather file



Indoor thermal comfort in Summer without an HVAC system
- Plot for the warmest day in each of the cities' weather file

The time series plots show a snapshot of the coldest day in each of the cities' weather data used in the simulation along with the resulting indoor temperature of THIMBY without the use of a heating system. This gives us a glimpse of a worst case scenario where the heating system is offline for unexpected reasons. THIMBY performs well in terms of maintaining a comfortable temperature indoors without active heating in a Bay Area climate but may require active heating in more extreme climates like Seattle and Vancouver.

The time series plots show a snapshot of the warmest day in each of the cities' weather data used in the simulation along with the resulting indoor temperature of THIMBY without the use of a cooling system. This gives us a glimpse of a worst case scenario for a summer day. THIMBY does not have a mechanical cooling system but will benefit from phase change materials installed in the ceiling to dampened indoor air temperatures. Occupants will require increased air movement through a ceiling fan to maintain comfort in these extreme summer days.

DAYLIGHT FACTOR

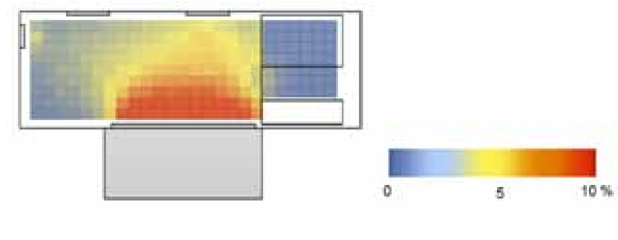
Daylight Factor (DF) is a ratio of indoor illuminance to outdoor illuminance. Under 2% (visualized in blue) indicates artificial lighting required for those areas as that portion of the floor space does not receive adequate daylight. Between 2% and 5% (visualized in green/yellow) indicates that the space is adequately lit by daylight, but may need artificial lighting at times. Over 5% (visualized in red) has ample daylight not requiring artificial lighting except at dawn and dusk. As the goal in the design is to reduce artificial lighting loads, this analysis is useful in determining where and how much artificial lighting is needed during daytime hours. The results show lighting is not needed for the majority of the house especially near the south facade; lighting may be needed at times on the west side; lighting is required in the bathroom and hallway.

DAYLIGHT AUTONOMY

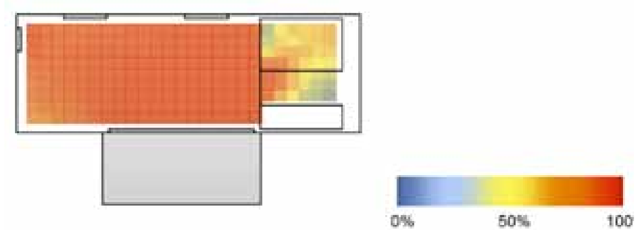
Daylight Autonomy (DA) is an annual daylighting metric visualizing the percentage of occupied hours the floor area receives more an appropriate illumination level, 250 lux. The DA value represents the percentage of floor area that exceeds the illumination level for at least 50% of the time. The results show all of the floor area west of the hallway, visualized in orange, to be illuminated above 250 lux for 100% of occupied hours. The bathroom and hallway are closer to 50% occupied hours above 250 lux visualized in yellow. The DA value is 93%. This means 93% of the house floor area receives the recommended amount of daylight for at least 50% of the occupied time. These results support that reduced artificial lighting is appropriate for this tiny house.

USEFUL DAYLIGHT ILLUMINANCE

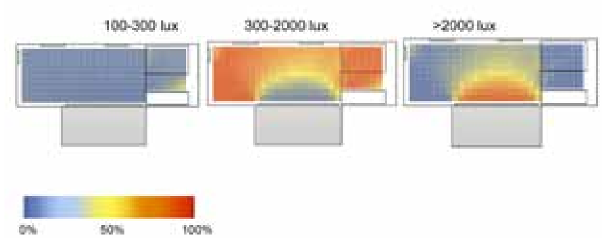
Useful daylight illuminance is similar to daylight autonomy, the annual occurrence of illuminance across a plane, only is it grouped into ranges that are useful for the occupant's visual comfort. The useful range is 300 lux to 2000 lux, with values below 300 lux not sufficient for lighting needs and above 2000 lux source of glare. The results show the entire floor area of the house is in the useful range 100% of occupied hours except for nearest the south facade. Near the south window, illuminance is predicted to be above 2000 lux which is above the recommended exposure. This analysis supports the reduction in artificial lighting.



3D Model showing Daylight Illuminance



3D Model showing Daylight Autonomy



3D Model showing Useful Daylight Illuminance

This Tiny House biult by CSU Sacramento uses a TRACE power conversion center. It is concealed behind a wood framed screen.

4 PLANNING COMMUNITIES

In the United States the average size of new single family homes grew from 1,780 square feet in 1978 to 2,662 square feet in 2013, despite a decrease in the size of the average family. The tiny house movement is an architectural and social movement that advocates living modestly in small homes. In addition to costing less, small houses encourage less cluttered, simpler lifestyles while reducing ecological impacts.

TINY HOUSING BOOM FOR THE HOMELESS

Dignity Village in Portland, OR, and Opportunity Village in Eugene, OR, once forget new ground in offering tiny house villages as transitional housing for homeless people rather than tents or dormitory style public housing. Now the concept has taken hold. Here are the four most recent projects:

NewField, NY	**Olympia, WA**	**Madison, WI**	**Austin, TX**
Second Wind Cottages 18 residents 18 houses planned open Jan. 29.2014 Cost estimate per unit: $12,000 plus labor	Quixote Village 29 residents 30 houses planned open Dec. 21.2013 Cost estimate per unit: $87,500	OM Village (occupy Madison) 10-15 residents 11 houses planned open Dec. 24.2013 Cost estimate per unit: $5,000	Community First! Village 200 residents Unit number undecided open Dec. 2014 Cost estimate per person: $30,000

4.1 Planning Communities

Carmen Guidi is founder of Second Wind Village, located just a few miles outside of Ithaca. The "tiny homes" provide shelter and independence for homeless men. Credit Jenna Flanagan

(Photo by Gay Huddle / Correspondent photo)

http://innovationtrail.org/post/tiny-houses-have-big-impact-homeless

Newfield, NY

Second Wind Cottage

SecondWind COTTAGES

written by Jenna Flanagan for Innovation Trail • Apr 20, 2016
(reprinted with permission)

The number of homeless New Yorkers seems to be on the rise, so much so that a group of 51 millionaires recently petitioned the state government to raise their taxes permanently from 7.65 percent to nearly 10 percent to "invest in pathways out of poverty up the economic ladder for fellow citizens."

Most of the funds and focus on homelessness is in New York City, where more than 100,000 people are without permanent shelter. But what if you find yourself homeless in upstate New York? Lack of funds and resources can make access to services much harder. However, one Ithaca-area man is trying to make a big impact on the homeless — one tiny house at a time.

Carmen Guidi is founder of Second Wind Village, nestled in Newfield, just a few miles outside of Ithaca. The collection of nine "tiny houses" built on his property wasn't inspired by the attention such structures have been getting lately.

Rather, Guidi said he was divinely inspired after good will trips to Honduras and Haiti. He also considered how he would want to live if he were homeless.

"I knew nothing about a tiny home anything. Once we started putting together these 'tiny houses,' I know I would like to live that way if I was that, and that's why these men do so well here."

The auto body repair tech created the cottage village as a nonprofit, and private donations and volunteers help build each $15,000 home. Guidi said the cottages meet a crucial need for the homeless.

"They give the men a level of dignity that they can't get anywhere else," he said. "Even though they don't own the houses, they still take an ownership, they take pride around the surroundings. Here's the thing, they want to stay in community, yet they want to have their own time, too, in their own space."

The cottages are like autonomous studio apartments, allowing the residents to regain a sense of normalcy with their own kitchen, bathroom and living space. Some even keep pets in their home.

Second Wind serves only homeless men, although Guidi hopes to expand the project to include individual housing for women and children at a separate location.

While he's not a professional social worker, Guidi has been reaching out to and building relationships with Ithaca's homeless for years.

"A lot of the times when people are put into the program-type models, they feel like a project. Here, the men, they don't feel like a project."

Just off Ithaca's main commercial boulevard, behind a popular multinational discount department store, is a field overgrown with underbrush and a thicket of trees. It's become an unofficial campground.

Most people might not notice it at all, but to the homeless of Ithaca and Tompkins County, it is well-known as "The Jungle."

The Jungle may look desolate and bleak, but that's not where all of the homeless in Ithaca find themselves.

Nels Bohn, director of Ithaca's Urban Renewal Agency, said the city successfully

houses most of their homeless. The "unsheltered" population, including those who live in The Jungle, is about 15 to 20 people.

"I think we pretty well know most of our homeless persons by first name and understand their needs a little bit better because we

Second Wind cottages is a cluster of small (16 X 20) houses intended for homeless men. The houses have been constructed on land provided by Guidi's Collision in Newfield, Tompkins County. Dec. 3, 2014
David Lassman | dlassman@syracuse.com

Second Wind Cottages in Newfield, NY provides cottages of about 320 square feet. (Second Wind Cottages)
Samantha Craggs, CBC News

have the advantage of being so small," Bohn said. "The disadvantage is once we fill up our emergency shelter or Magnolia House project, we don't have any more room. There's just limited capacity."

As a smaller city, Ithaca has about 40 emergency shelters, one new shelter called Magnolia Project, for women and children, and about 100 permanent supportive housing units.
Bohn said the city is supportive of Guidi's Second Wind project but noted that addressing the issue means more than just a roof over their heads and food on the table.

Both men agree that for anyone to begin to address homelessness in a metropolis like New York City or in smaller upstate cities like Ithaca, it first has to begin with affordable housing for everyone.

According to the Office of Temporary and Disability Assistance, which offers housing and support services, Gov. Andrew Cuomo is proposing a five-year, $20 billion investment. Half will go to build 100,000 units of affordable housing across the state; the other half will be used to build out the state's supportive services and 20,000 more beds to accompany state services.

As for the Second Wind Cottages, Guidi is already working on adding nine more cottages with a main house that can accommodate some of the state services that are needed.

There is no timeline on how long each resident can stay. So far, the longest have been there three years, a triumph for some of the residents.

The city of Ithaca has helped Guidi attain rental funds for the men, but even as they expand, Second Wind Cottages has a waiting list of almost 30 people.

photos by © John Light/BillMoyers.com

4.2 Planning Communities

Residents moving in to Quixote Village in Olympia, Wash.
(WNV/Quixote Village) https://wagingnonviolence.org

http://www.yesmagazine.org/new-economy/tiny-house-villages-for-the-homeless-an-affordable-solution-catches-on

photos by Jeremy Bittermann for The New York Times

Olympia, WA

Quixote Village

written by Erika Lundahl for yesmagazine
• Feb 20, 2014
(reprinted with permission)

"The typical development for extremely low-income housing is trending up toward $200,000 per unit. That's a lot of bills," says Jill Severn, a board member at Panza, a nonprofit organization that sponsors another tiny-house project called Quixote Village. (The organization's name is a play on Sancho Panza, Don Quixote's sidekick in Miguel de Cervantes' classic novel.)

Quixote Village opened in Olympia, Wash., right before Christmas. But it began in February 2007 as "Camp Quixote," a protest held in a city-owned parking lot. A group of homeless people assembled there to oppose an Olympia ordinance that made it illegal to sit, lie down, or sell things within six feet of downtown buildings. When police evicted the campers eight days after the protest began, the Olympia Unitarian Universalist Congregation stepped in to help, offering temporary refuge on their land.

For five years, the camp's location rotated, moving and reassembling every 90 days at one of several different local churches. Panza was formed by a corps of volunteers from the faith communities assisting the camp, and the organization worked with the city council to secure and rezone a parcel of county-owned industrial land near a community college and create a permanent site for the village. In December of 2013, the residents of Quixote Village settled into their new homes there.

Quixote Village has fostered a positive relationship between its residents and local government and police, says Severn. Despite this, the project was held up in court for a year by a local organization of businesses and landowners called the Industrial Zoning Preservation Association, which cited concerns over the potential impact on local businesses in a nearby industrial park.

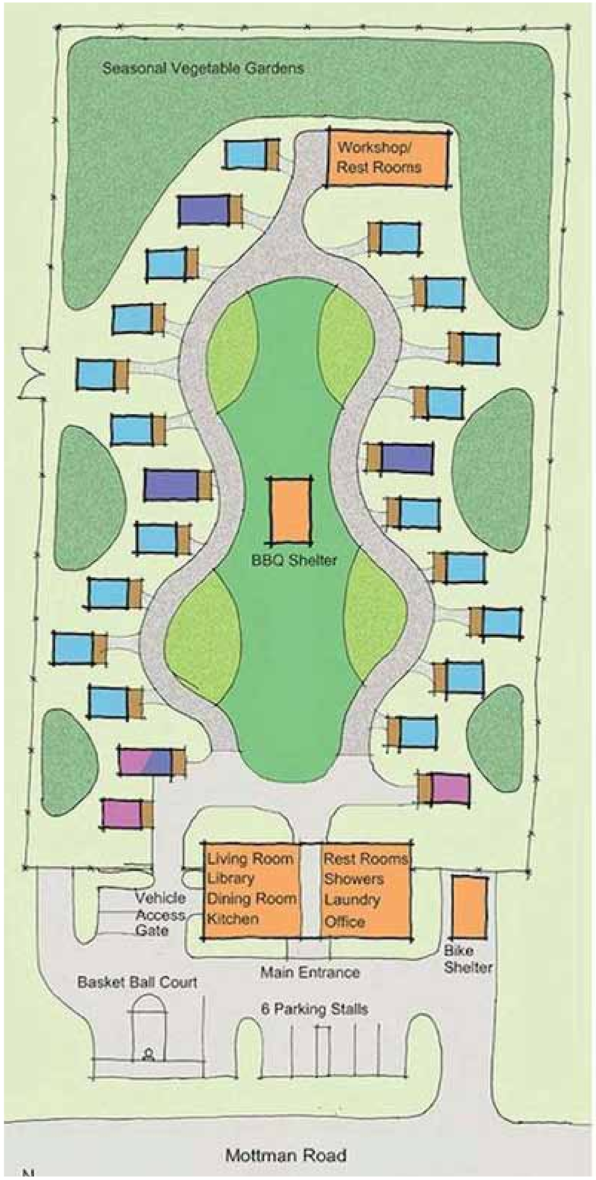
Panza used the time to fundraise and build an outreach campaign to win over the public. They had the support of legions of volunteers, mostly from local churches, who had staffed the camp.

"Having hundreds of [residents] get to know people that were homeless made a huge difference in the success of getting this off the ground," says Severn.

Today, the 30 structures that make up Quixote Village are home to 29 disabled adults, almost all of whom qualify as "chronically homeless," by the standards of the U.S. Department of Housing and Urban Development.

The residents also have a common space with shared showers, a laundry, garden space, and a kitchen. By sharing these amenities, the community was able to increase the affordability of the project and design a neighborhood they believed would fit their needs and make them more self-sufficient.

The shared space has also helped them create a supportive community. The residents, who are self-governed, have developed a rulebook that prohibits illegal drugs and alcohol on the grounds and requires that each member put in a certain number of service hours per week. They meet twice a week in the evenings



http://quixotevillage.com/photo-gallery/

Photography by Leah Nash for BuzzFeed

to discuss problems or concerns and to share a common meal that they take turns cooking.

The main complaint right now, says Raul Salazar, the village's program manager and only full-time staff member, is that the postal service still hasn't started delivering mail.

The cost of units at Quixote Village is significantly higher than at Second Wind—about $88,000 per unit—but that's still less than half the cost of the average public housing project, according to Nan Roman, president and CEO of the National Alliance to End Homelessness. Quixote has had access to state funding and local community grants, as well as private funding from individuals, businesses, and two Native American tribes. The project also received a Community Development Block Grant for $604,000 from the State of Washington Department of Commerce and a $1.5-million grant from the Washington State Legislature.

Two architecture and design firms, MSGS Architects and KMB Design Groups, also contributed design services pro bono, and the Thurston County Commission is leasing the land to Quixote for $1 per year.

Erika Lundahl wrote this article for YES! Magazine, a national, nonprofit media organization that fuses powerful ideas and practical actions. Erika is a freelance writer living in Seattle

An architect's rendering of Quixote Village in Olympia, Wash. Illustration courtesy Krista Schooley An artist rendition of what a tiny home community for the homeless could look like.

4.3 Planning Communities

http://www.yesmagazine.org/new-economy/tiny-house-villages-for-the-homeless-an-affordable-solution-catches-on

photos by https://www.facebook.com/OMBuild/photos/

Madison, WI

OM Village (Occupy Madison)

OM Village

written by Erika Lundahl for yesmagazine
• Feb 20, 2014
(reprinted with permission)

Many other tiny-house projects are just beginning to get of the ground, raise money, find land, and gain approval from local officials and members of the public. But the unorthodox nature of the small houses presents unique legal zoning limitations and barriers that limit where tiny houses can be stationed.

In Madison, Wisc., Occupy Madison has been facing this very challenge, as the group forged ahead with plans for a tiny house village.

In the spring of 2011, prior to the launch of the Occupy Wall Street movement, a series of protests at the Wisconsin State Capitol—focused on the state's controversial anti-collective-bargaining bill—prompted additional legislation that prohibited groups from gathering without a permit. When the protests joined forces with Occupy in the fall of 2011, this created a unique opportunity for the voices of the many homeless people in Madison to be heard.

"There were some great moments throughout the Occupy movement where a lot of dialogue was going on between the people without homes and the people with homes," says Allen Barkoff, one of the board members of Occupy Madison, Inc., a nonprofit formed in December 2012 to address the need for legal places where homeless people in Madison could congregate and stay safe. The organization first looked into buying an apartment building or a shared house for the homeless but ultimately settled on tiny houses as the most flexible and economical way to create homes for people.

In this case, the cost of building the tiny homes comes to around $5,000 each, funded by private donations and an online crowd-funding campaign. The nonprofit also plans to apply for some city grants. Each home will come with a propane heater, a composting toilet, and an 80-watt solar panel array—and will be about 98 square feet in size, 99 if you include the porch. (The volunteers enjoy the joke: "We are the 99 square feet!")

But the question of where the houses can legally be located is still up in the air. Volunteers are now building houses for six people. Because of a recent ordinance change, the houses are allowed to sit on church property in groups of three. City regulations also permit them to be placed on the side of the road, as long as they are relocated every 48 hours. But Madison's snowy winter makes the houses hard to move, explains Barkoff.

Now Occupy Madison, Inc., is in the middle of a lengthy process to purchase a parcel of land on the east side of the city to accommodate 11 houses, along with a central building (a converted gas station) that can serve as a workshop for making more homes. This spring, they will continue to hold neighborhood meetings about the project, talk with police, and work with the Madison Planning and Development Department—and, eventually, the city council—to negotiate zoning issues for the village.

http://tinyhousefor.us/news/some-cities-install-homeless-spikes-others-build-tiny-housing/

photos by © OM Build

Erika Lundahl wrote this article for YES! Magazine, a national, nonprofit media organization that fuses powerful ideas and practical actions. Erika is a freelance writer living in Seattle

https://www.generosity.com/community-fundraising/om-village-tiny-homes-for-people-without-homes

Green Design Studio, Edward Kuharski, Architect

http://tinyhousefor.us/news/some-cities-install-homeless-spikes-others-build-tiny-housing/

http://publicinterestdesign.blogspot.com/2015/01/tiny-houses-by-and-for-homeless-in_14.html

4.4 Planning Communities

photos by Joy Diaz for KUT News

http://www.yesmagazine.org/new-economy/tiny-house-villages-for-the-homeless-an-affordable-solution-catches-on

photo by (Credit: Mobile Loaves & Fishes)

Austin, TX

Community First! Village

written by Kelly McCartney for yesmagazine
• Dec 16, 2013
(reprinted with permission)

In Austin, Texas, a project to offer affordable housing to some 200 chronically homeless citizens is on the move. Community First! Village, which has been in the planning stages for nearly 10 years, is set to soon break ground on a 27-acre property sprinkled with tiny houses, mobile homes, teepees, refurbished RVs, a three-acre community garden, a chapel, a medical facility, a workshop, a bed and breakfast, and an Alamo Drafthouse outdoor movie theater.

Supporter Alan Graham, of Mobile Loaves and Fishes, notes that the price of not housing these folks costs taxpayers about $10 million a year, not to mention the emotional and psychological tolls on the homeless themselves.

Graham says that, for the most part, local residents seem to be in favor of the project. "We haven't converted everybody," he says, "but when people come out here they go, 'Oh!' They see a chapel, they see medical and vocational services on site, and they learn that residents will not live there for free. They'll pay a monthly rent."

Graham has been working with the homeless in his community for more than 14 years and cites broken families as the leading cause of homelessness. With Mobile Loaves and Fishes, Graham has not only helped feed the homeless all these years, but he has helped transition them into homes and jobs as well.

And he has given them hope. Graham views Community First! as the next step in that mission and the next step toward solving homelessness in the U.S.

As the local NPR station (KUT) reports, Alamo Drafthouse's founder Tim League is another outspoken cheerleader for Community First! Village. In fact, he calls it "the very first 'Yes, in my backyard' project."

Map Community first village _ http://mlf.org/community-first/

The Topfer Health Resource Center is now serving residents of the Community First Village. Photo courtesy of Mobile Loaves & Fishes

image by www.nbcnews.com

Photo courtesy of Weird Homes Tour

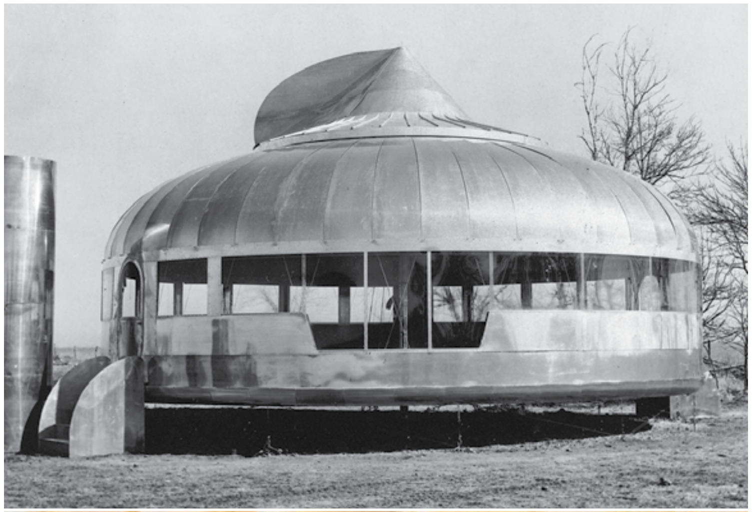
Learn more at http://mlf.org/community-first/. Source/Photo: Mobile Loaves and Fishes. All Rights reserved.

Community First! – photo by Roldolfo Gonzalez

Image by: Why Hunger Blog

5 Glossary of Portable Architecture

This chapter references some iconic 'tiny house' projects relevant to anyone studying the historical context of small dwleeings, affordable housing and evolutions of the build environment

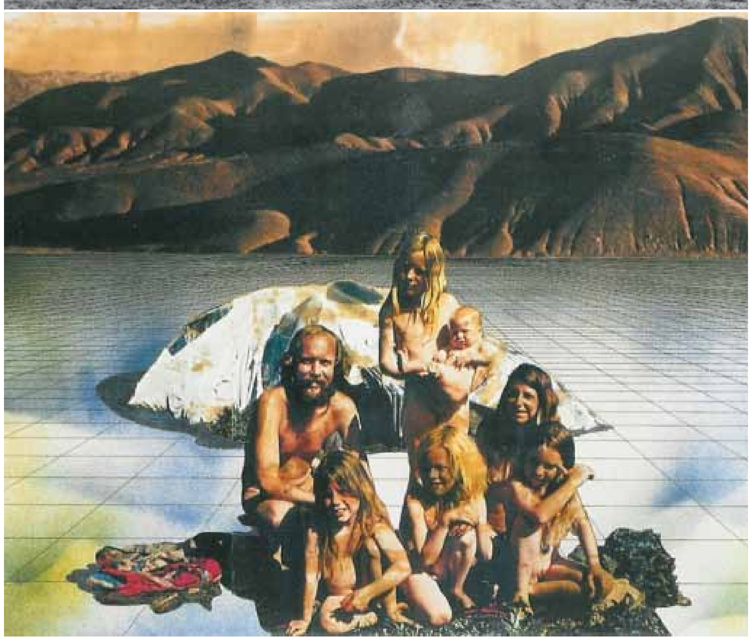


5.1 Dymaxion House

by Buckminster Fuller

"Dare to be naïve."

Conceived and designed in the late 1920's but not actually built until 1945, the Dymaxion House was Fuller's solution to the need for a mass-produced, affordable, easily transportable and environmentally efficient house.



5.2 Life, Supersurface

1972, Super Studio

"We'll listen to our hearts and our breathing. We'll watch ourselves living."

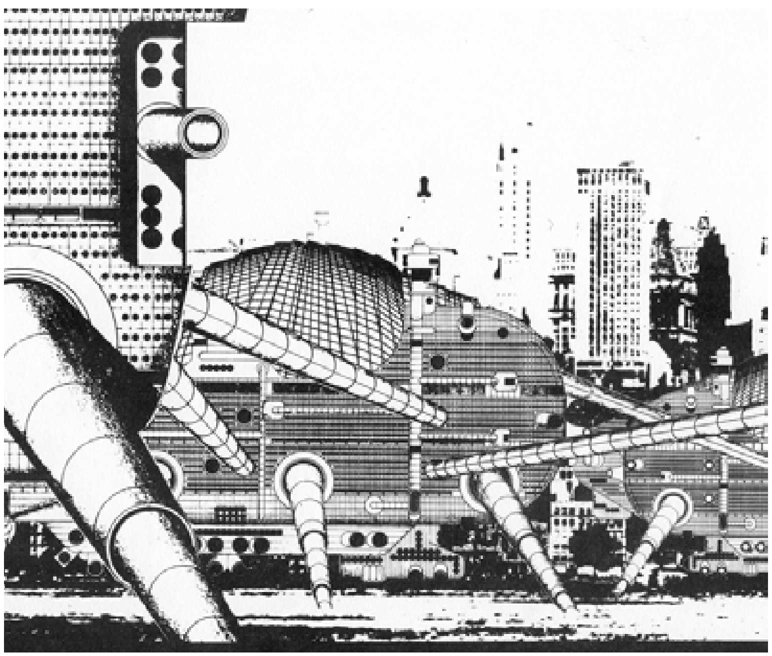
Half a century ago, a group of 20-something architecture students from Florence decided to assume the small task of conceiving an alternative model for life on earth.

5.3 The Mind Expanding program

Haus Rucker & Co

1968

Haus-Rucker-Co aspired to extend people's psycho-physical experiences through art and architecture.



5.4 The Walking City

by Ron Herron & Archigram 1963

The walking city was neofuturistic, anti-heroic and pro-consumerist, drawing inspiration from technology in order to create a new reality that was solely expressed through hypothetical projects.

Glossary of Portable Architecture

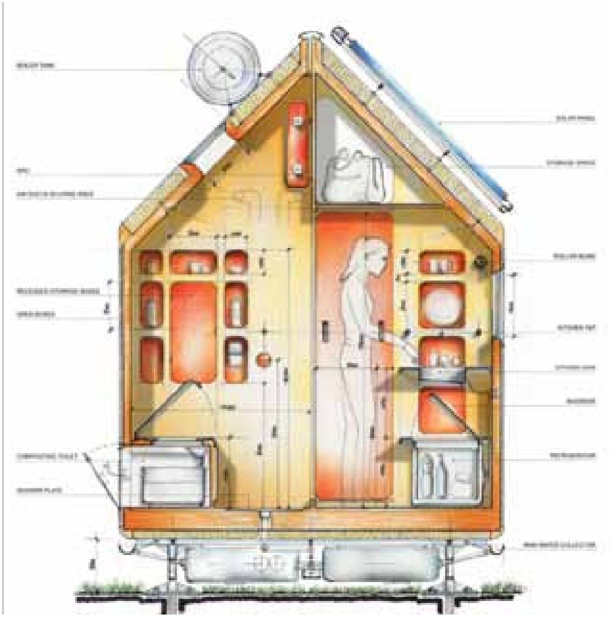
5.5 Dwelling for a Tokyo Nomad Woman Toyo Ito

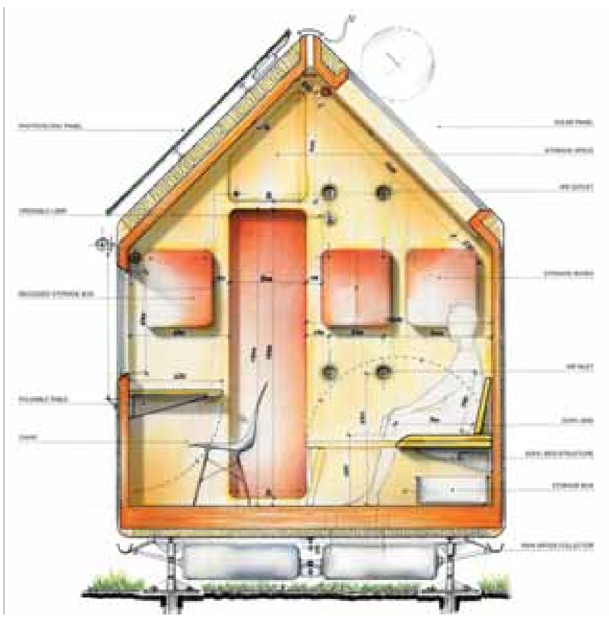
1985 and 1989

Toyo Ito's project is based on a scenario where most of the domestic functions are dissolved in the metropolis while the living unit becomes a reduced entity providing only minimal shelter and the access to the informational network.

5.6 Emergency Shelter by Shigeru Ban

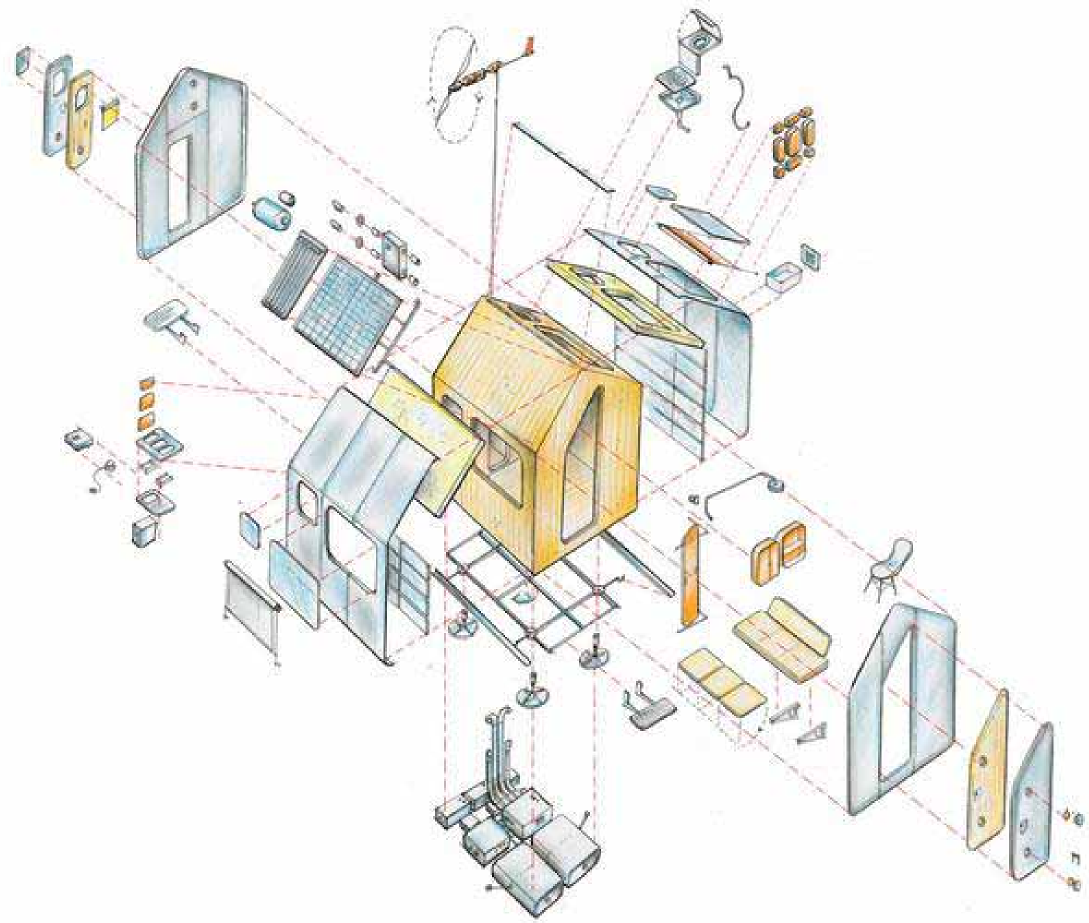
Pritzker Laureate Shigeru Ban may be as well known for his innovative use of materials as for his compassionate approach to design. This structure is built for emergeny shelter out of cardboard and plastic crates.





5.6 Diogene by Renzo Piano

Renzo Piano, known for big things like the Pompidou Centre in Paris and the Shard in London, tries his hand at tiny with Diogene, which Domus calls "a technically perfect and aesthetically attractive refuge, testing the potential of the minimalist house."



COMPANY PROFILE : ECOLOGIC ARCHITECTS

The EcoLogic Architects is an **architectural** and **ecological** design 'lab' providing state of the art and conscientious architectural design services. Our goal is to create high performance architecture with a new age of contemporary design tools. With our advanced techniques we design in harmony with nature.

Based in Monterey, California, with satellite offices in Los Angeles, USA and Amaliada, Greece we can serve local as well as international clients regionally and around the globe. Our work spans several continents and a very diverse palette of functions. We resolve spaces from mega urban scale to tiny small and compact. Our design seeks to harmonize functional beauty, energy efficiency, and ecological integrity for maximum human comfort. A celebration of space and form for human enjoyment..

We specialize in :

- Innovative high-performance architectural design
- Integration of renewable energy and energy efficiency measures
- Enhancing on-site ecosystem services
- Sustainable Masterplanning
- Environmental urban design

Key Awards and Collaborations include

- 1st Prize 2008 Beijing Olympics World Park with Jourdan & Mueller, PAS Frankfurt
- 1st Prize 2016 Mock Firm International Student Design Competition with Hartnell Engineering and Architecture Research Team (HEART)
- Monterey Bay Shores Ecoresort, with Rana Creek Habitat Restoration, Carmel Valley and BSA Architects.
- Gaia Hotel Napa Valley, with Mickey Muennig - First LEED Gold Hotel
- "Principles of Green Building Design" publication funded by Bay Area Career Pathway Alliance

EcoLogic Architects was founded in 2005 by Thomas Rettenwender, Constantine Papachristopolous and Niklas Spitz.

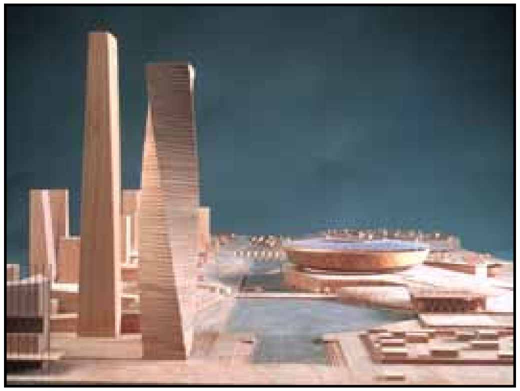
Thomas holds a **Bachelor of Arts** from Trinity College, Dublin, Ireland in Philosophy and Mathematics. He also holds a **Master of Arts** in Philosophy from Trinity College, Dublin, Ireland.

He also holds a **Magister Architecture (M.Arch.)** from the University of Applied Arts, Vienna, Austria. During his studies he was awarded two scholarships to attend Southern California Institute of Architecture (SCIArc) in Los Angeles, California. He has studied with internationally renowned architects Zaha Hadid, Wolf D. Prix, Lebbeus Woods, Hans Hollein, Laurids Ortner, Karl Chu, Eric Owen Moss and Greg Lynn.

After studying in Europe, Thomas apprenticed with Big Sur Architect Mickey Muennig from 2003-06. He became the Lead Architect at Rana Creek Living Architecture in 2007. In 2008 he received his Architects License from the California Architects Board. He is also LEED accredited professional. Since starting EDL he has practiced Architecture primarily in Central California but also in a diversity of settings like Panama, Switzerland, Dubai, and Ulan Batar, Mongolia.

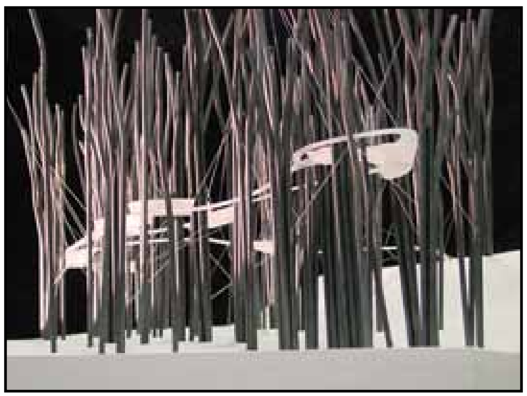
Since 2009 he has taught Green Building Design courses at Monterey Peninsula College and UC Santa Cruz. He has also taught at Hartnell College, Rancho Cielo Construction Academy, Middleberry College, and San Jose City College. He has taught a diverse list of courses including "Principles of Green Building Design", "Ecologic Urban Design" and "Smart Home Automation". Thomas is currently Lecturer at UC Santa Cruz. teaching the **Tiny House Design Lab.**

ECOLOGIC DESIGN LAB : COMPANY PROFILE



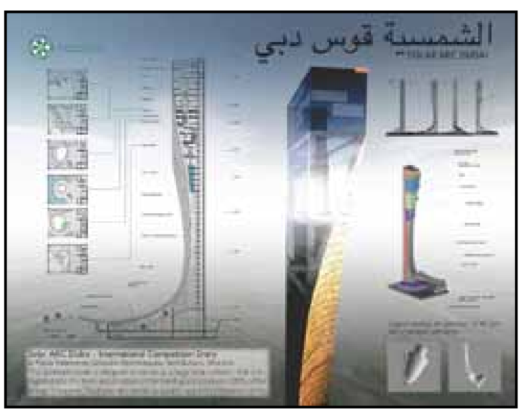
2008 Beijing Olympic World Park
1st Prize & $60k Award
Location: Beijing, China
with PAS Jourdan & Mueller, Frankfurt

Gaia Hotel, Napa Valley CA
Architectural Design & Project Management
New Construction
with Mickey Muennig, Architect

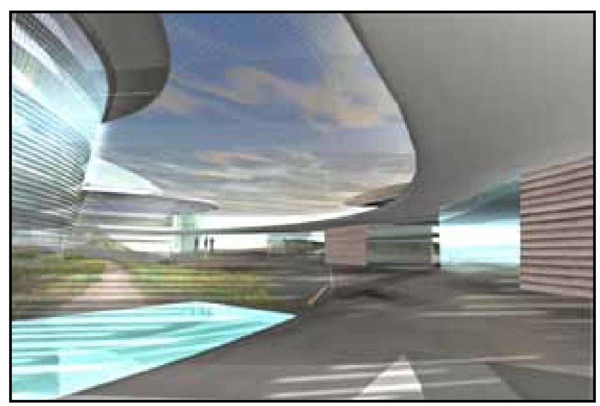


Redwood Gateway Interpretive Center
Humboldt County, California
with Save the Redwoods League
and Prof. Greg Lynn

Monterey Bay Shores Eco-Resort
Location: Monterey, California
with Rana Creek, BSA Architects



Solar - Arc, Dubai
Landmark Green Technology Tower
International Design Competition Entry
with Hyphae Design Lab, Oakland



Point Molate Casino, San Francisco Bay,
Guidiville Tribe of Pomo Indians
with Rana Creek Habitat Restoration