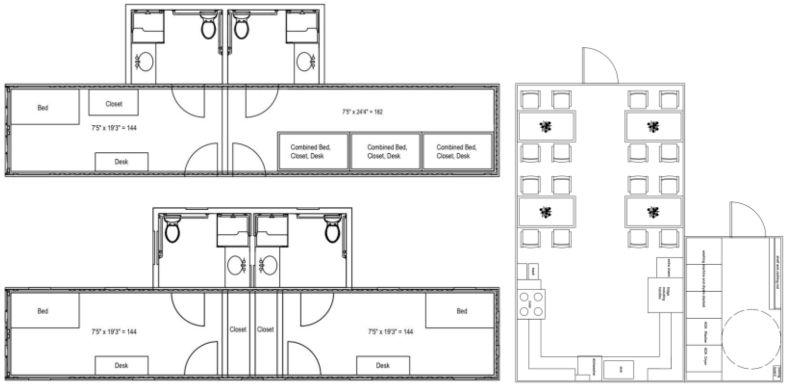
ARCHITECTURE AT ZERO 2023

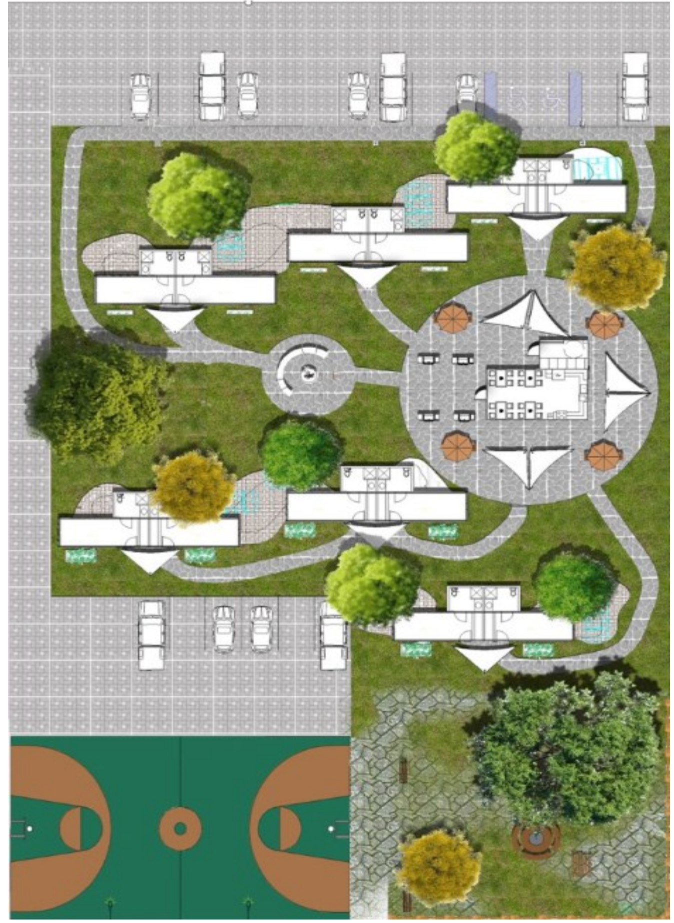
A Design Competition for Decarbonization, Equity, and Resilience in California

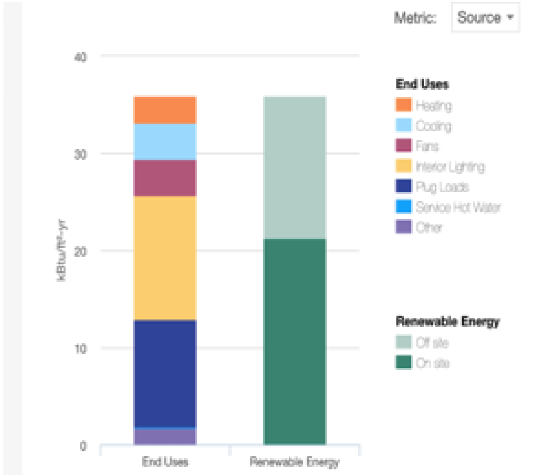
Think Outside the Box

High School
2022-2023 Architectural Engineering Class

While we do not intend to enter this challenge to win, we believe that we offer unique and innovative solutions to achieve the most equitable, eco-friendly, and sustainable design. We are a high school Architectural Engineering class, but do not have the professional skills or tools to do the 3D renderings or the hourly energy calculations. What we propose is a solution that conserves not only energy, but also water and thermal energy. Water has played a critical role in the life of Allensworth, both scarcity when neighboring farms pumped the area dry and flooding due to lack of levies that are more common around the more affluent communities.



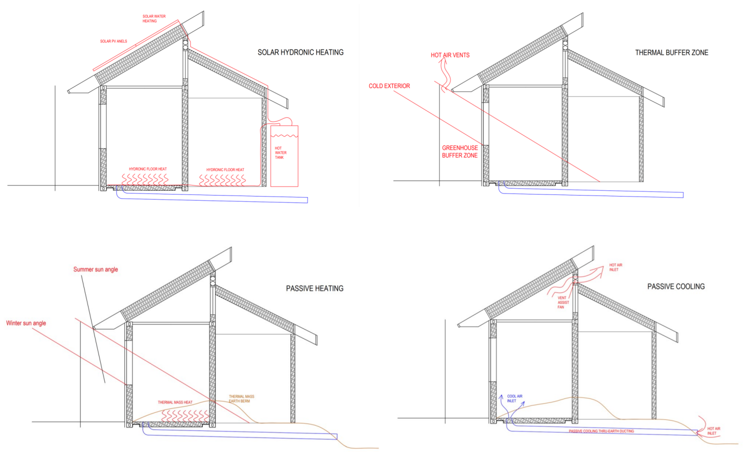




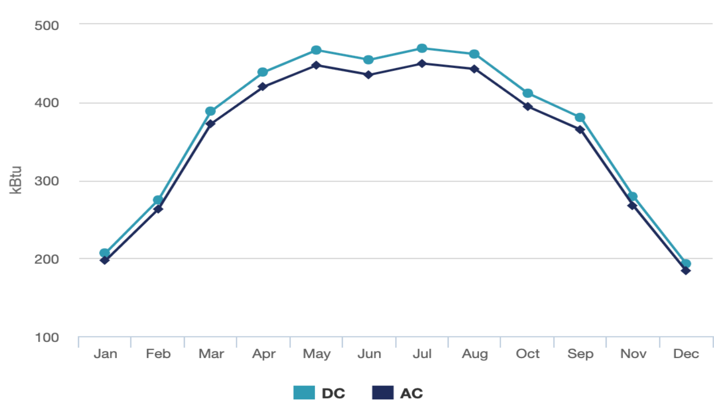
Building Energy Impacts and End Uses are based on **code compliant prototype buildings** modeled by NORESCO in their Impact Analysis. Actual building energy consumption will vary from modeled results.

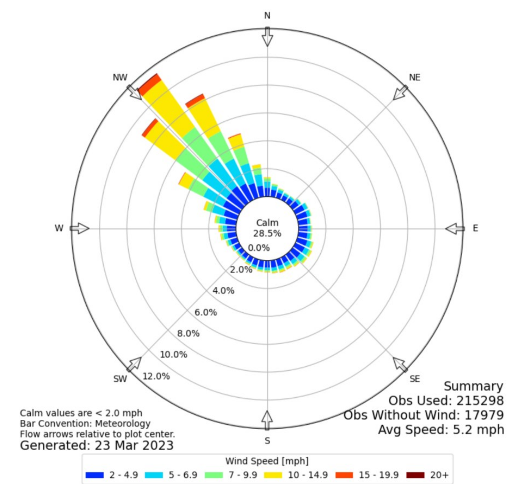
Estimated Source EUI: **35.91** kBtu/ft²-yr
Estimated Source Energy Consumption: **5.17** MBtu/yr

End Use	Subtotal (kBtu/ft²-yr)	Percent
Heating	2.75	7.66%
Cooling	3.74	10.43%
Interior Lighting	12.77	35.57%
Plug Loads	11.00	30.62%
Service Hot Water	0.11	0.31%
Fans	3.77	10.49%
Other		
Exterior Light	0.33	0.92%
Heat Rejection	0.34	0.94%
Pumps	1.10	3.06%
Total	**35.91**	**100.00%**



ANNUAL AC & DC PRODUCTION





Project Narrative

While we do not intend to enter this challenge to win, we believe that we offer unique and innovative solutions to achieve the most equitable, eco-friendly, and sustainable design. We are a high school Architectural Engineering class and do not have the professional skills or tools to do the 3D renderings or the hourly energy calculation, but what we propose is a solution that conserves not only energy, but also water and thermal energy. Water has played a critical role in the life of Allensworth, both scarcity when neighboring farms pumped the area dry and flooding due to lack of levies that are more common around the more affluent communities.

We make use of passive cooling and heating through thermal mass and using an Earthship model greenhouse thermal buffer. All of this is done by using shipping containers as our building blocks, which also enable us to raise the living modules above the flood levels with minimal cost. This design has already been used and approved in Tulare County and would serve as a model for low cost and equitable building in the community of Allensworth. Our goal is not only building a farm school housing project but provide a model and fabrication training for the entire community. To that end, we are submitting a plan for only the housing section of the Farm Lab project. Not only is our goal to meet the requirements set out by Architecture at Zero, but we also seek to serve and engage the community of Allensworth to help them provide a building model for Tulare County, once again restoring it to a place of significance in the state.

While our buildings are simple in design and the layout optimizes solar performance, our site plan implements a variety of unique features. All our landscaping is edible. From the fruit and nut trees that are used for shade, to ground covers of carrots and lettuce and shrubs of okra and kale, we seek to optimize the use of reclaimed water from the housing units to provide food for the dining hall and to be sold at our community-facing fruit stand. Even our dining facility has a green roof to reduce thermal transmission but also provide another area to provide food. While the specified dining facility has a small area, we provide abundant outdoor dining, BBQs, and relaxation areas. We use a lighted basketball court as our fire apparatus turn around area, again to provide an area for fellowship and community engagement.

Each building module employs similar features. We use earth berms on the side of each container for thermal mass as well being the holding area for our grey water and rainwater tanks. The south-facing entrances are covered with a vented greenhouse walkway that creates a thermal buffer and the shade sails can be installed in summer and removed in winter. We also have included large trees with benches as places for students to do their work and build community. The ADA-Compliant dorms are the ones closest to the cafeteria for ease of travel. Each dorm is oriented to maximize solar production and to ensure equity for heating and cooling systems.

Our design uses passive heating by configuring the roof overhang, window placement, and thermal mass to heat up during the day and radiate during the night. We achieve passive cooling by using metal ducting that is buried underground and high windows that create a strong convective flow. Our buildings are oriented, and the roofs are sloped for ideal solar production, and we use both photovoltaic and water heating panels. The heated water is for domestic use as well as radiant floor heating in the winter. We collect the rainwater from our metal roof, and store and filter it for domestic use. Then, gray water is stored in other tanks underground and combined with the post-septic tank effluent, to water our landscaping. All trees and plants are fruit, nut, or edible crops that are irrigated with reclaimed water through drip irrigation. By utilizing water three times, we drastically reduce the demand on our local aquifer.

Again, our goal is to not only provide a student housing design, but a way to engage the community of Allensworth to restore its place of significance in the history of California. We will do this through developing and modeling the use of Earthship container-housing that will have a net zero energy consumption, utilize water three times to enable the community to grow more food without having to import or pump water from the local aquifers. This holistic approach will enable the community to thrive while other may struggle with lack of water and power in our changing environment.

Site Plan Annotated:

1 – ADA qualified units close to parking

2 – Larger 188 sq ft housing units

3 – Standard 144 sq ft housing units

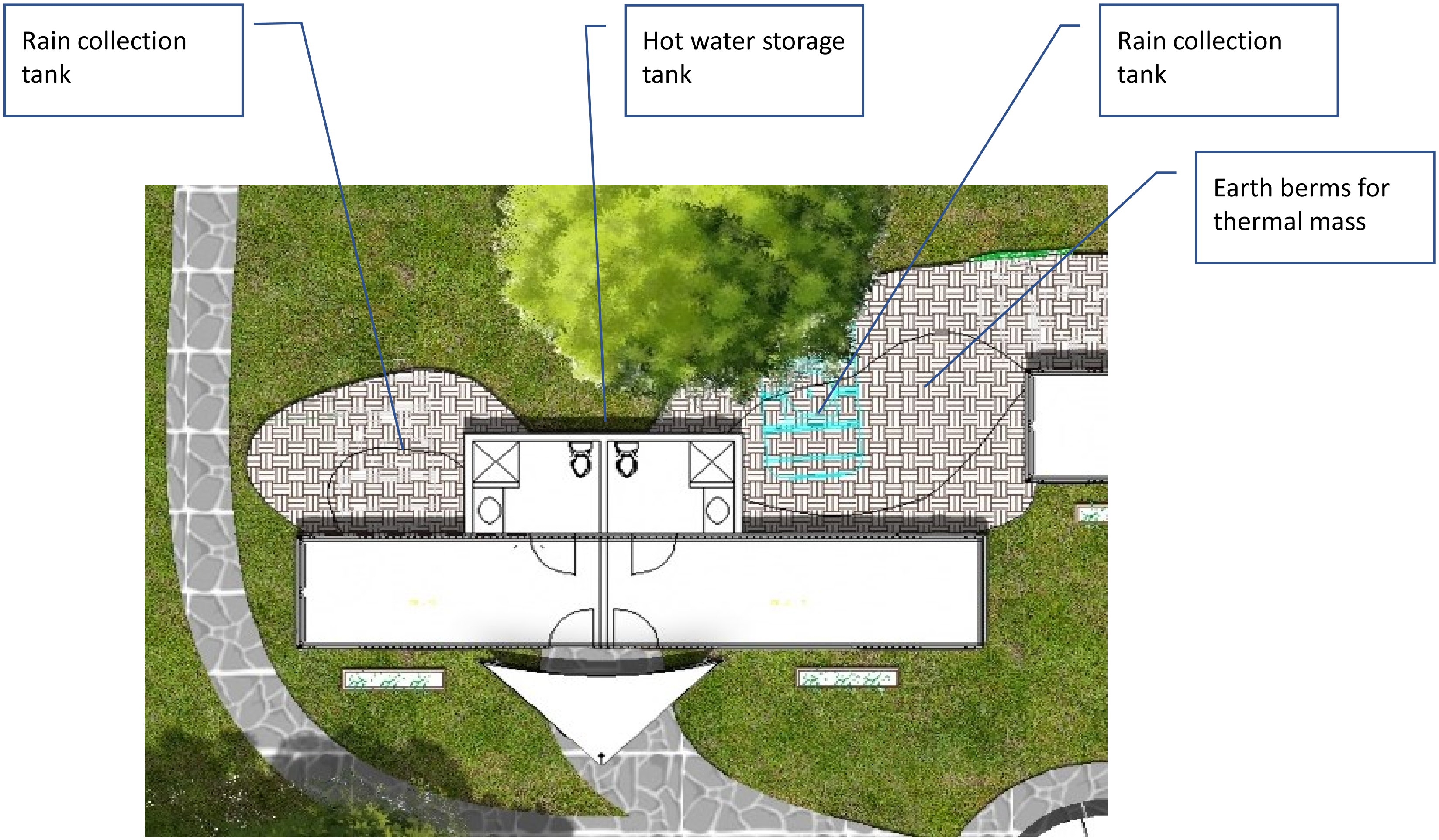
4 – Dining hall and laundry area with barbeque and gathering space

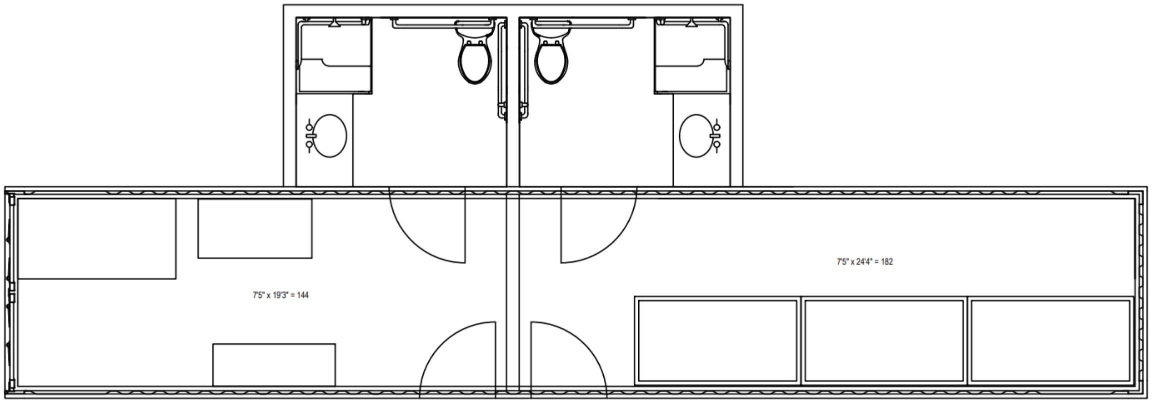
5 – Secondary gathering space with firepit

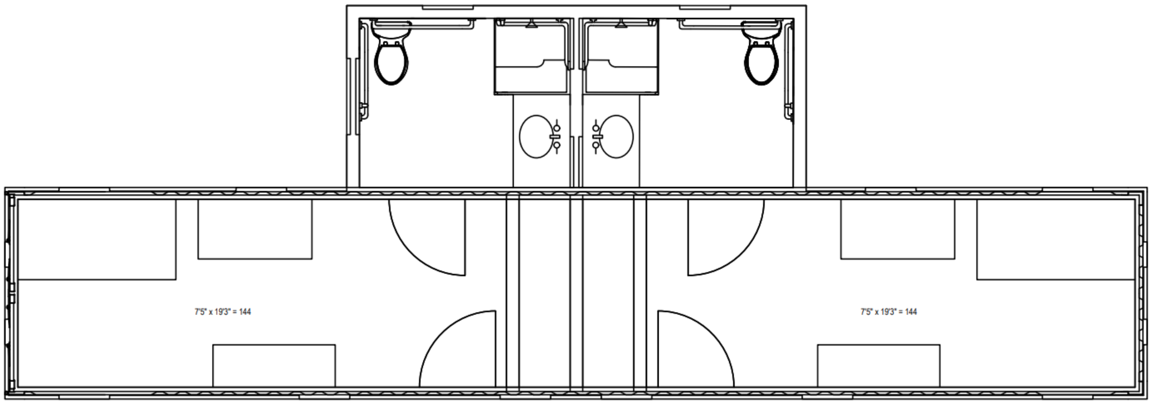
6 – Recreation basketball court / fire truck turn area

7 – Park gathering area with benches

Site Plan Details



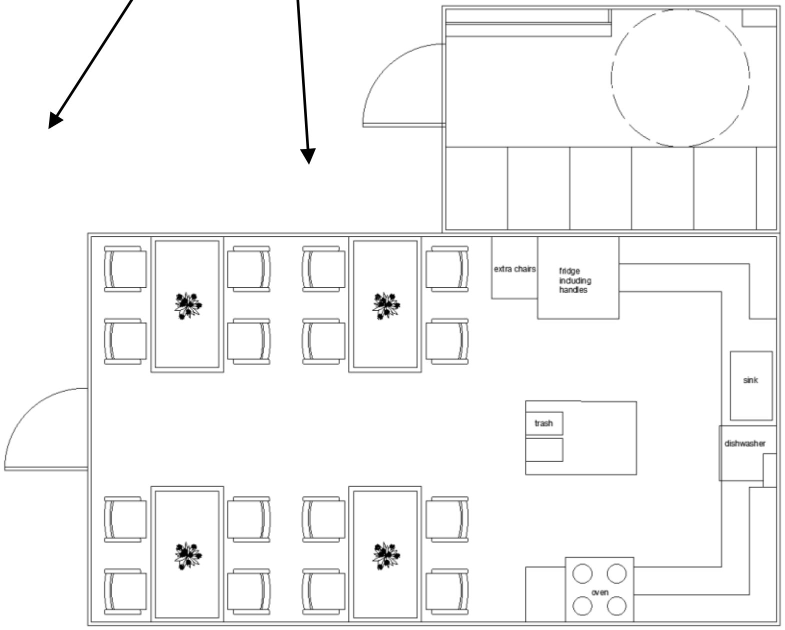




Module with one 144 sq ft and one 168 sq ft unit in 45' container

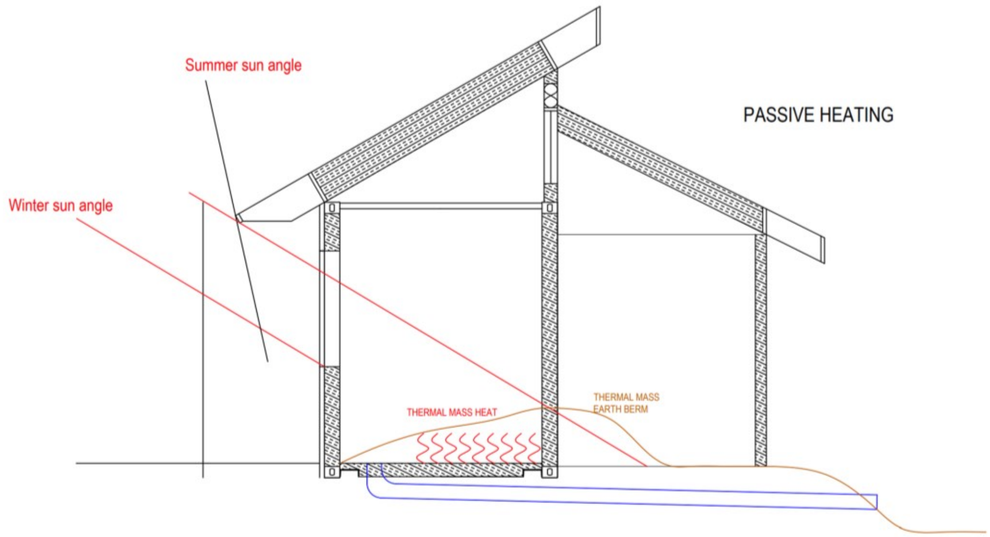
Module with two 144 sq ft units with closets

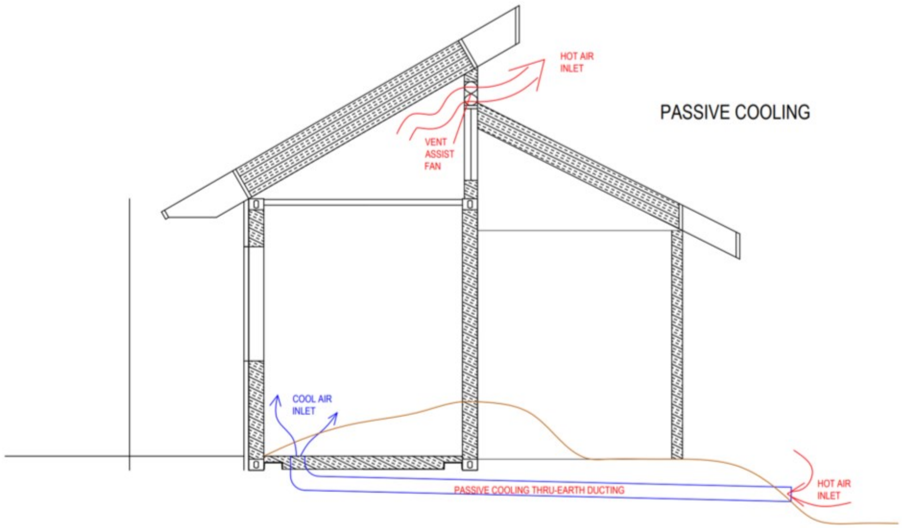
Dining room, kitchen, and laundry room



Perspective Views

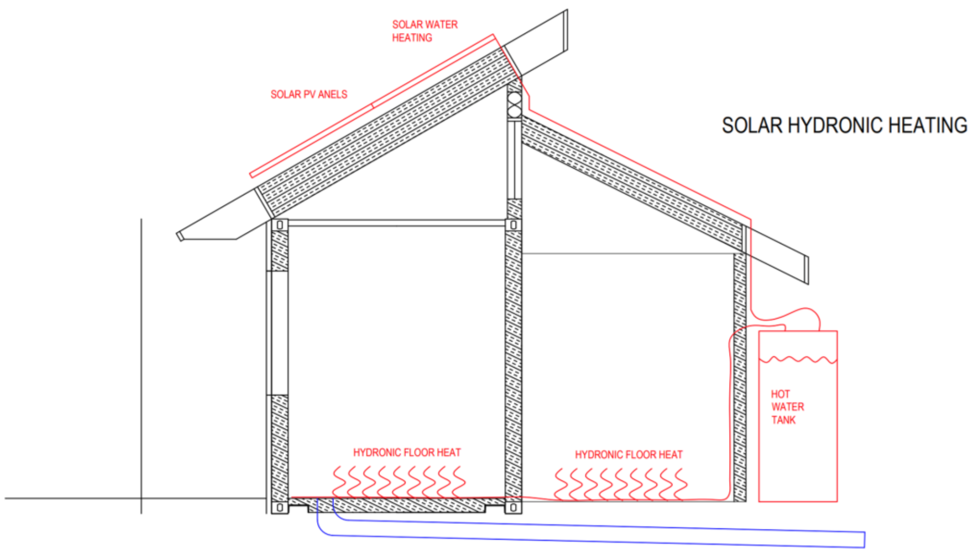
Illustrated Sections

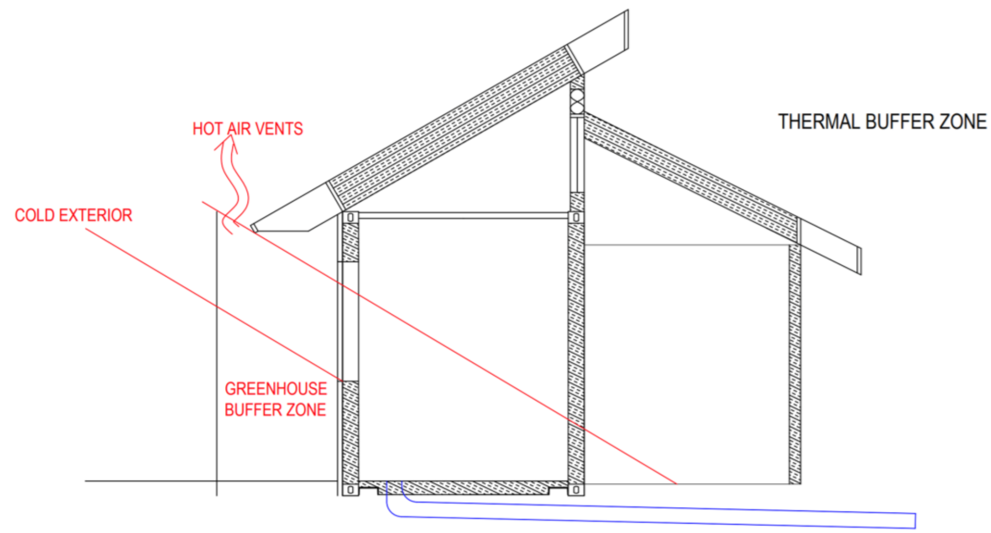




- One of the most significant features of our design the passive heating and cooling. The orientation of the buildings, overhang of the roof and window placement optimizes the heating of the thermal mass of the earth berm during the winter and having shade in the summer. The passive cooling is facilitated by the high ceilings that slope to the north and powered by solar-powered vent fans that draw air through 40’ of steel ducting that is buried under the earthen mounds.
- The earth mounds serve multiple purposes. They conceal the rainwater and gray water tanks and are used to be the thermal mass for passive heating in the winter. In the summer, the earth pulls heat from the metal container.

Illustrated Sections





- •We propose to use solar water heating for both domestic and hydronic floor heating in the winter.
- •Common in an Earthship design, we propose to utilize a greenhouse buffer zone on the southern side of the dorm unit.
  - •During the summer, the sun heats up the space, but it is vented at the roof.
  - •In the winter, the space can be more closed and will warm up.
  - •This allows vegetables to be grown along the walkway in a warm environment, even in the winter.

System Details	
Heating System	Passive heat plus hydronic floor heat
Cooling System	Passive cooled metal ducting and thermal mass plus SEER 22 mini-split heat pumps
Ventilation System	Solar-powered convective flow augmentation fans
Lighting System	100% LED with vacancy sensors
Domestic Hot Water System	100 gallon solar-heated
Renewable/Generation System	8 kW (DC) PV total and 2 water heating panels per dorm unit

Annual End-Use Summery Table

ZERO CODE™

Code Pathway: ◉ Prescriptive ○ Performance

Climate Zone	13 *
Number of Stories	1 *
Add Another Use	*

Selected Use Type(s):
Apartment

APARTMENT

delete

Gross Floor Area (sq.ft)	144 *

ON-SITE PV SYSTEMS

Default Values estimate on-site building PV system potential. Uncheck Use Default Values to enter custom inputs. If your building has multiple PV systems, add them below.

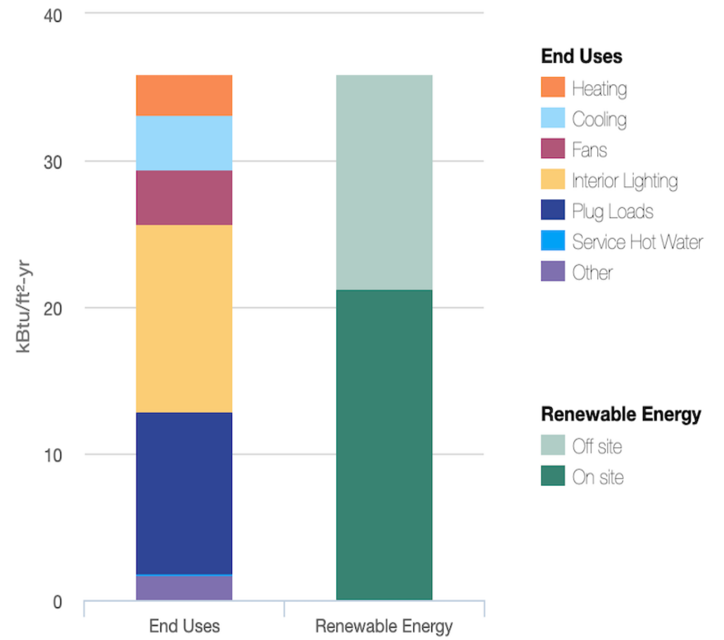
PV SYSTEM

Set Default Values delete

Estimated Area for Collectors	78.6 * sq.ft *
Module Type	Standard *
Losses (%)	10 *
Array Type	Fixed - Open Rack *
Tilt (Degrees)	30 *
Azimuth (Degrees)	180 *
Inverter Efficiency (%)	96 *

Add another PV System

Metric: Source



Building Energy Impacts and End Uses are based on **code compliant prototype buildings** modeled by NORESCO in their Impact Analysis. Actual building energy consumption will vary from modeled results.

Estimated Source EUI: **35.91** kBtu/ft²-yr
Estimated Source Energy Consumption: **5.17** MBtu/yr

End Use	Subtotal (kBtu/ft²-yr)	Percent
Heating	2.75	7.66%
Cooling	3.74	10.43%
Interior Lighting	12.77	35.57%
Plug Loads	11.00	30.62%
Service Hot Water	0.11	0.31%
Fans	3.77	10.49%
Other		
Exterior Light	0.33	0.92%
Heat Rejection	0.34	0.94%
Pumps	1.10	3.06%
Total	**35.91**	**100.00%**

Monthly End-Use Energy Consumption Bar Chart

While it would be easy to simply add 4 PV panels to each dorm unit to meet zero energy, we employed several other innovative methods to achieve that goal.

PV

- Apartment dwelling in climate zone 13 with 144 sq ft calculates out to about 36 kBtu/sq ft^2/yr, but the specs say to use 15. (Zero-code.org)
- Passive cooling and heating should reduce HVAC electrical cost in half
- Lighting is all LED with large indirect lighting through windows on northern and southern aspect
- 4 solar panels would offset the entire 36 kBtu, but using the 15 kBtu requirement we propose to use 2 panels per 144 sq ft unit
- This does not include the offset for passive heating and cooling
- Batteries would be included due to the unstable grid in the area

Solar-heated water

- 2 panels per unit would provide the hot water for domestic and hydronic floor heating

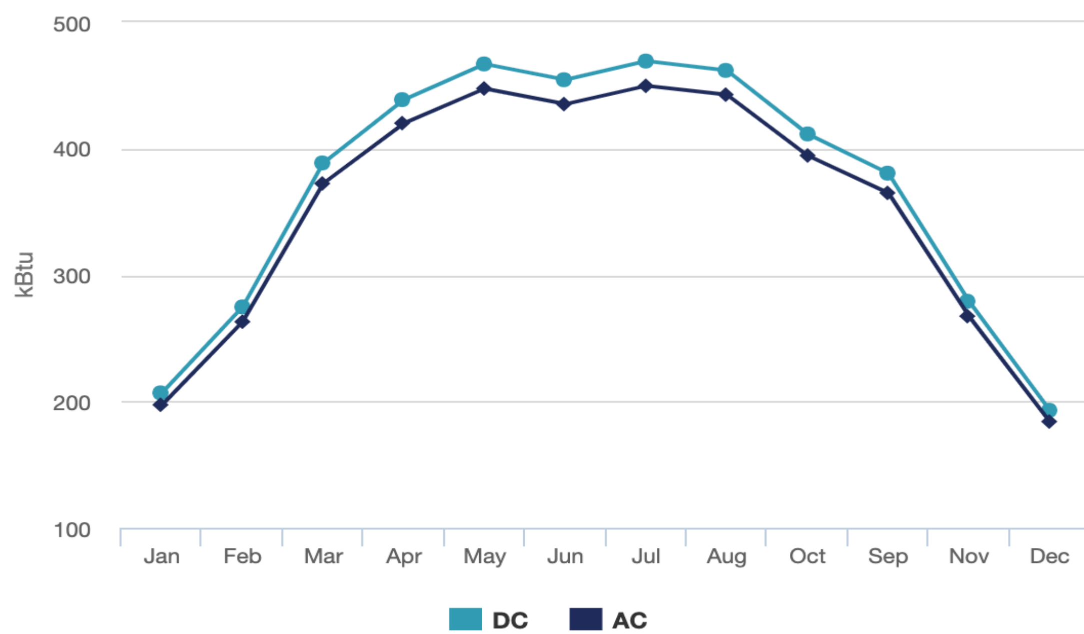
Water collection

- We propose to collect rainwater and gray water to offset the use of domestic water to irrigate the edible landscaping

FileID	93193.tm2
City	FRESNO
State	CA
FTE Solar Hours (hrs/yr)	1,651

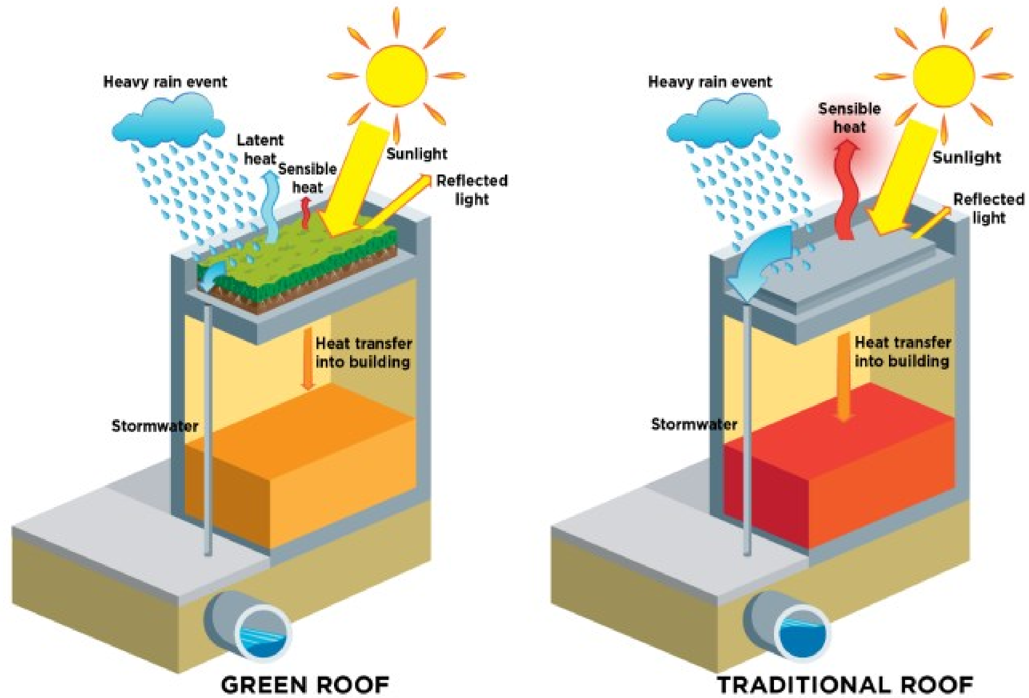
	AC Production (kBtu)	DC Production (kBtu)
January	197	207
February	263	275
March	372	389
April	420	439
May	447	467
June	435	454
July	450	469
August	443	462
September	394	412
October	365	381
November	267	279
December	184	193
Total	**4,238**	**4,425**

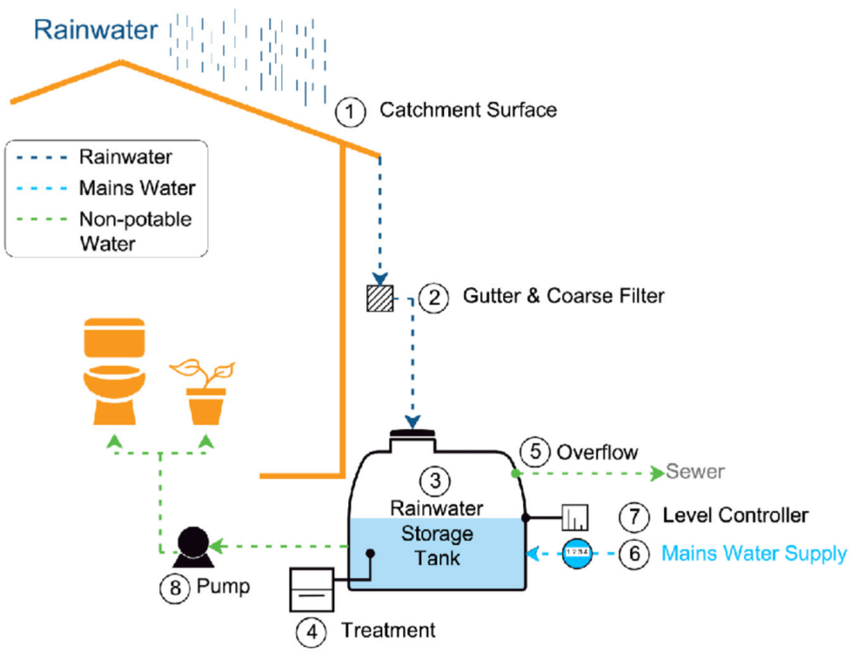
ANNUAL AC & DC PRODUCTION

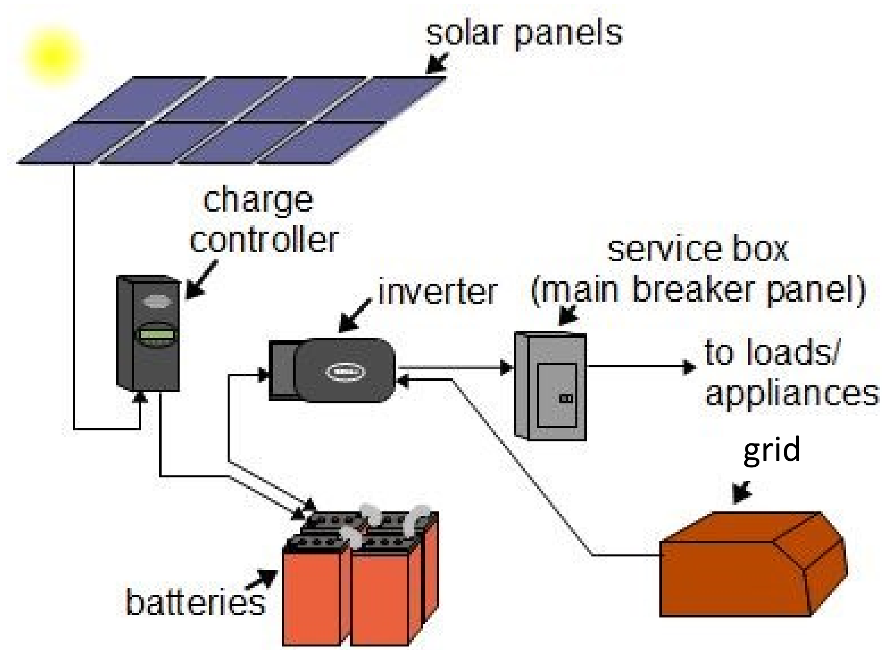


Details of Renewable Energy Systems:

- 2 panels per dorm unit x 12 = 24 panels, 8kW with battery storage
- Passive heating and cooling
- Extensive green roof
- Rainwater and gray water collection

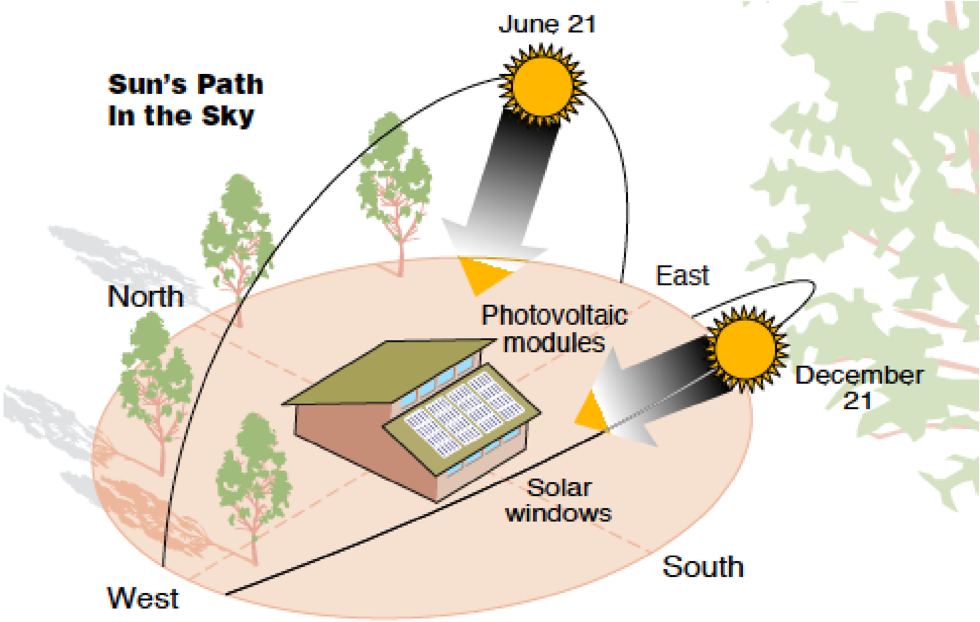


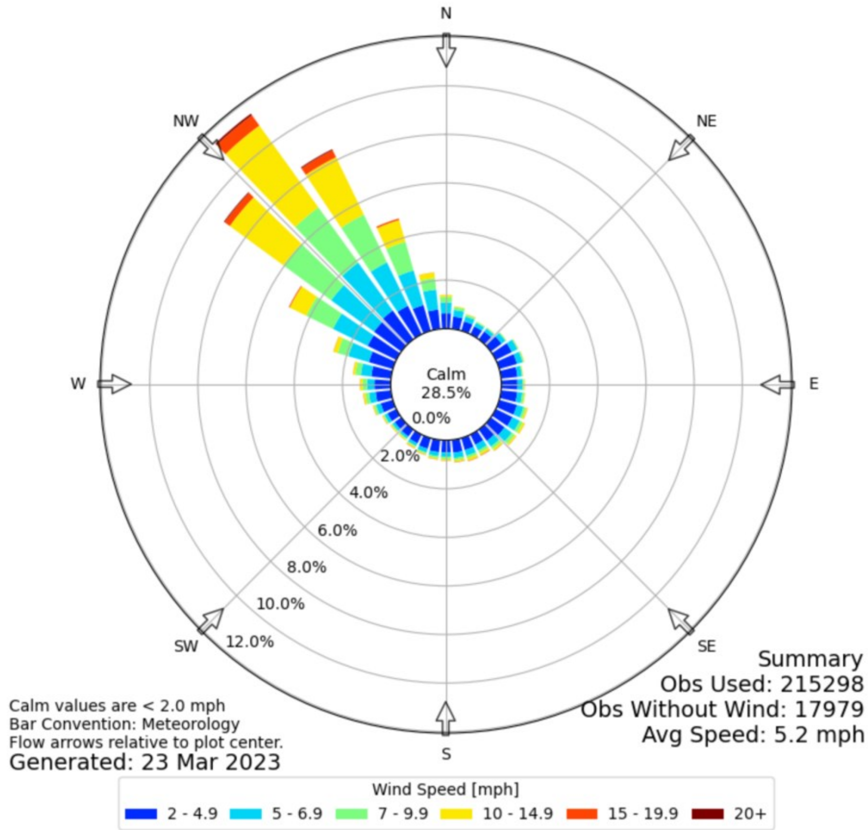




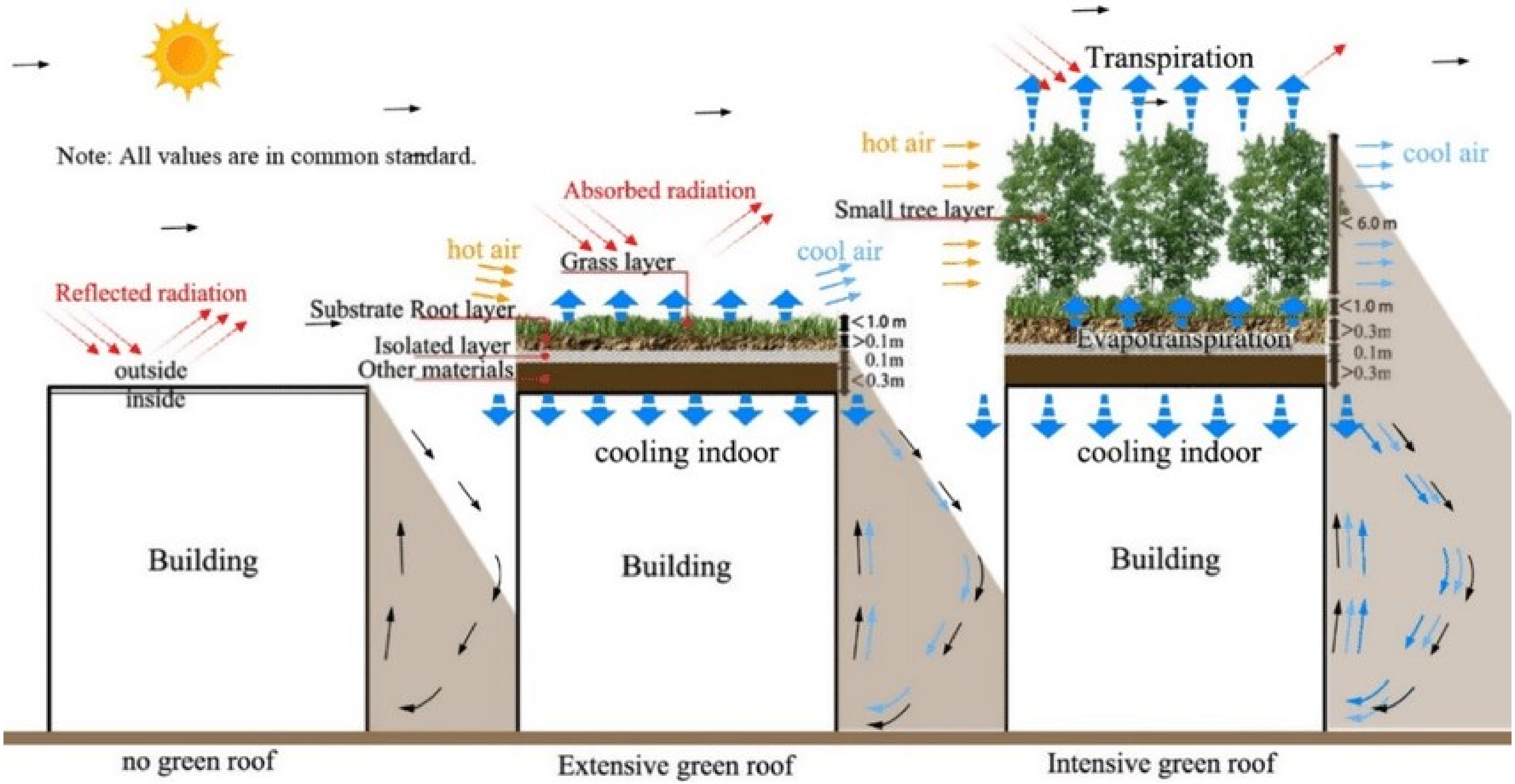
Weather and Orientation

- All dorm unit are oriented with the large windows facing south, but with extended overhanging eaves for summer heat protection. This design is as old as the cliff dwellings in the Southwest and duplicated in the designs of Eichler
- Large, sloping roofs are facing south for optimal solar gain and easy rainwater collection. The single slope roof also creates a higher window placement for optimized convective heat flow to facilitate passive cooling.
- Prevailing wind during most of the year, including summers, is from the Northwest so our crank-out windows allow for good ventilation





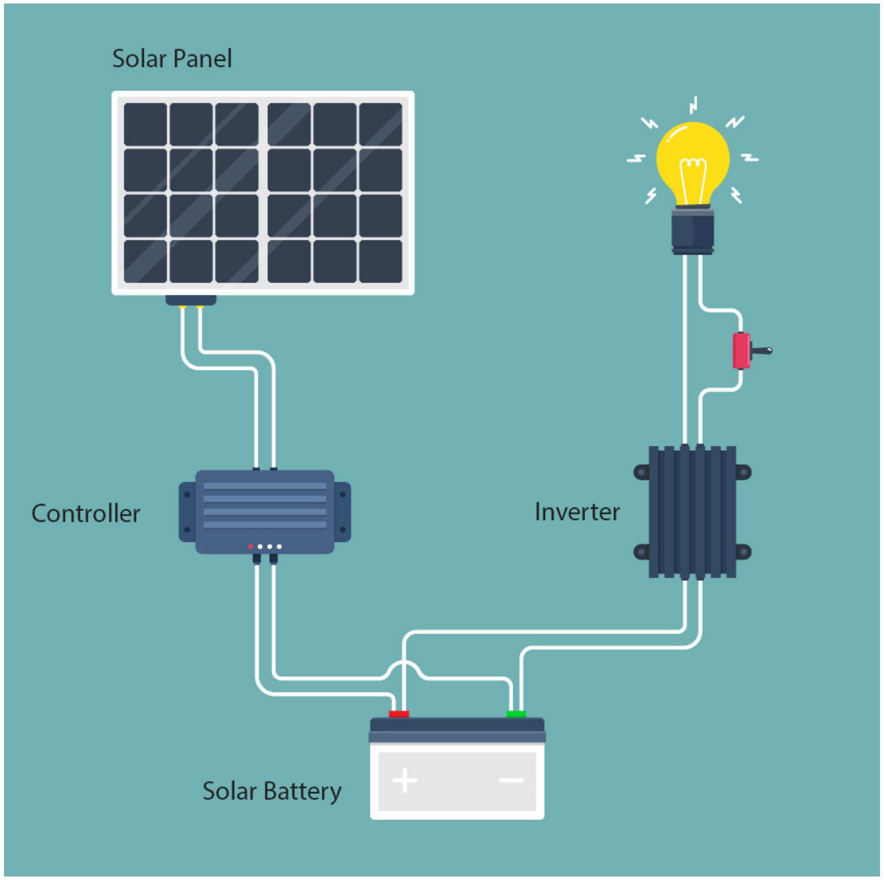
Extensive Green Roof



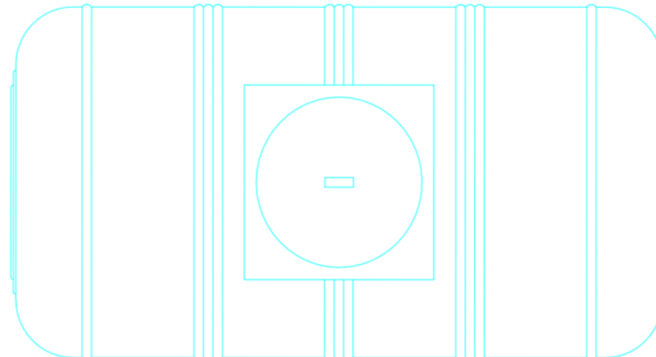
We propose an Extensive Green Roof on the dining building, using edible plants as the coverage, including corn, tomatoes, and lettuce

- An extensive green roof reduces heat transmittance
- Soil acts as an inertial mass with a high thermal capacity and low thermal conductivity
- Measured heat reduction in the interior can range between 70-90%

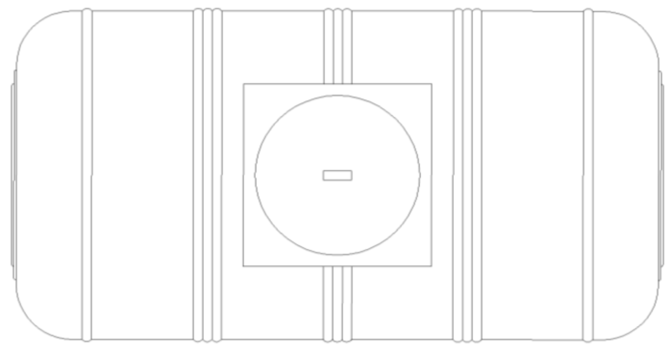
Storage Systems



Our site will be equipped with a 24kWh lead acid battery system. This system will supply our site with electricity in emergency situations.



There are 6, 2650-gallon, rainwater collection tanks in berms of dirt around our site. These tanks will collect rainwater that supplies our site with water throughout the year. This will overall reduce our water usage.



There are 6, 2650-gallon, septic tanks in berms of dirt around our site. These tanks will collect grey water that we will reuse for toilet water and watering plants around the site. This will overall reduce our water usage.

Each container will have an 80-gallon hot water tank. This tank is part of our solar hydronic heating system that will provide us with hot water throughout the day.

Shipping containers vs. conventional housing

Advantages

- They are a sustainable building material. They are made from recycled materials and can be reused multiple times.
- They allow the buildings to be raised without the need for concrete slabs or additional framing.
- They are strong and durable. They can withstand extreme weather conditions and are not susceptible to pests or rot.
- They are relatively inexpensive to purchase and build.
- They are easy to transport and can be assembled quickly.

Disadvantages

- They are not designed for human habitation. They may need to be modified to meet building codes and provide adequate insulation and ventilation.
- They can be difficult to customize. They have a limited floor plan and may not be suitable for all types of housing.

Net carbon savings for solar PV and water heating

Solar PV panels convert sunlight into electricity. This electricity can be used to power homes and businesses, reducing the need for fossil fuels. A study by the Lawrence Berkeley National Laboratory found that solar PV can save an average of 9,000 pounds of carbon dioxide emissions per year for a typical household.

Water heating

- Solar water heaters use the sun's heat to warm water. This can reduce the need for electricity or natural gas to heat water, saving energy and money.
- A study by the Solar Energy Industries Association found that solar water heaters can save an average of $1,000 per year on energy costs.

Growing food on site vs. having it delivered

- Reduced food miles: Food that is grown on site does not need to be transported long distances, which reduces greenhouse gas emissions.
- Increased food security: Growing your own food can help to ensure that you have access to fresh, healthy food, even during times of food shortages.
- Improved nutrition: Homegrown fruits and vegetables are often more nutritious than those that are purchased from grocery stores.
- Reduced cost: Growing your own food can be a cost-effective way to feed your family.

Passive heating and cooling
Passive heating and cooling is a design strategy that uses the sun's energy to heat and cool buildings. This can reduce the need for energy-intensive heating and cooling systems, saving money and energy. Passive heating and cooling can be a cost-effective way to reduce energy consumption in buildings and reduce carbon emission even further.

- Orientation: The orientation of a building can be used to maximize the amount of solar heat that it receives in the winter and minimize the amount of solar heat that it receives in the summer.
- Insulation: Insulation can help to keep a building's temperature consistent throughout the year.
- Natural ventilation: Natural ventilation allows fresh air to flow into and out of a building, helping to cool it in the summer and warm it in the winter.

HEAT	Is the project planting trees that will provide shade to buildings, homes, sidewalks, streets, or parking lots?	Y	Our project utilizes native trees such as oak trees and multiple types of nut and fruit trees to provide shade to pedestrians to minimize the effects of extreme heat and sun. The trees also support the environment surrounding our project allowing for an increase in biodiversity
	Is the project enhancing insulation of homes?	Y	Asphalt and photovoltaic panels contribute to urban heating, so we plan to use light-colored porous paver driveways and metal roofing with extensive shade coverage of the grounds. In addition, thick walls with a large r value will mitigate the transfer of heat and will allow for cooling mechanism to use less energy in maintaining a comfortable temperature for the residents.
	Is the project installing cool roofs?	Y	Since we are collecting rainwater from our roofs, we are utilizing light colored metal roofing to both maintain the purity of the water and reduce reflections and heat that would impact residents. The dining room will utilize a green roof, covered in soil and native plants to reduce urban heating by providing a large buffer that will absorb heat and keep the dining room cool while promoting biodiversity.
	Is the project reducing electrical grid demand and household costs associated with cooling?	Y	Instead of just using photovoltaic panels to bring in more energy than our heat pumps use in cooling and heating, our project uses several methods s of passive cooling and heating. We are utilizing underground piping to bring in cool air, a large thermal mass to absorb heat during the day and release the heat during the cold night, and hydronic heating powered by our solar. These forms of passive cooling and heating will significantly reduce the need for energy usage and the heat pumps are only needed during the most extremes meaning we are limiting our energy usage and supplying the grid with
	Is the project providing a community cooling center?	N	The space allotted for the student housing is insufficient to also provide shelter from the heat from those of the community but will be sufficient for the residents
	Is the project adding permeable land cover?	Y	Our project is utilizing porous concrete on top of drainage gravel, allowing for rainwater to drain and refill the aquifer. Minimal concrete will be used to comply with driving and ADA walkways, allowing all other surfaces to be landscaping. https://www.cemexusa.com/products-and-services/concrete/types-of-concrete/pervious-concrete
	Is the project replacing agricultural lands (croplands, rangelands, or pasturelands) or natural land cover (trees, grasslands, shrublands, watersheds, or wetlands) with pavement or buildings? (Negative co-benefit.)	Y	The land was previously used for farming and now we are using edible plants, trees, and native vegetation for landscaping. In addition, part of the land will be used for agriculture as the students will be able to have a hands-on experience and test their knowledge of agriculture
	Please add any additional measures employed to address this impact.		
PRECIPITATION CHANGE **(e.g. drought, extreme precipitation events)**	Is the project setting up an ongoing mechanism to conserve water?	Y	Our homes will collect rainwater and recycle grey water, water that has been already used but can be used for other sources. The gray water is then used for irrigation of plants in a drip system and toilet water. The recycling of water will cut our water usage down and over time greatly conserve water.
	Is the project promoting improved soil health, soil quality, or soil stability?	Y	By using native trees and plants for our landscaping, the plants will increase the soil health by bringing carbon and useful nutrients to the soil through decayed plant matter that will strengthen the soil health and promote future growth of plants. In addition, the large roots of oaks and fruit trees will help ad stability to the soil by adding structure to prevent dust storms and break down previously unable soil like patches of clay.
	Is the project restoring wetlands, watersheds, or riparian buffers?	N	The project is located in the historic natural lakebed of Lake Tulare and the project does not focus on restoring that body of water. Our plan seeks to use all water on the property at least twice and have zero net diversion of water off of the property so that it is percolated into the soil.

PRECIPITATION CHANGE (cont.)	Is the project planting native, drought-tolerant vegetation?	Y	Our selection of plants is native and food-producing and drought tolerant, as we have selected plants from the surrounding areas that are resilient against heat. In addition, we have chosen fruit-producing plats such as avocados, citrus, and tomatoes to provide a stable source of learning for the agricultural students and crops that can be sold in the produce market and teach the students how to manage to sell their goods and providing a steady income.
	Is the project changing permeable surfaces to paved surfaces? (Negative co-benefit.)	N	As we are utilizing shipping containers raised off the ground, so we aren't utilizing a concrete slab. 100% of the property is permeable with sufficient clearance to allow drainage into soil. Our concrete will be permeable and able to drain in the case of flooding to replenish ground water.
	Is the project increasing water use? Negative co-benefit.	Y	We are collecting rainwater and using gray water to plant our food-producing landscape, drastically reducing water use
	Please add any additional measures employed to address this impact.		
WILDFIRE	Does the project involve fuels management work to maintain ecosystem health in a high priority landscape?	Y	Since we are utilizing rainwater and gray water, we are able to water our food-producing landscaping, effectively reducing fire risk without increase water usage or fuel reduction.
	Does the project involve rehabilitation work in a high priority landscape impacted by wildfire?	N	The project is not actively taking measures in rehabilitation work as the area of the project is not impacted by wildfire due to its current agricultural use.
	Does the project involve fire hazard prevention work to mitigate wildfire threats to communities?	Y	Our project is utilizing multiple measures to reduce the spread of fire. First, our buildings are constructed using minimal combustible materials on the exterior. In addition, our landscaping and plants have specifically been spaced and placed with fire hazards in mind reducing fast growing weeds and bushes to again minimize fire spread.
	Is the project implementing other types of forest or other ecosystem management treatments to reduce wildfire intensity or reduce potential impacts of wildfires?	Y	Since we are utilizing rainwater and gray water, we are able to water our food-producing landscaping, effectively reducing fire risk without increase water usage or fuel reduction.
	Is the project implementing other fire mitigation or prevention measures for non-forested habitats that may be impacted by wildfire?	Y	With 24,000 gallons of rain and gray water storage on site, our project has enough water to help fight local fires before they get out of control.
	Does the project involve new construction in a high priority landscape for reducing or preventing wildfire threats? (Negative co-benefit.)	N	The plot was previously farmland and is not significant in reducing wildfire threats and isn't located in a high-risk area as the project is located in historic lake Tulare which has flooded and does not have high fuel loading.
	Does project include a backup power source (e.g., battery charged by renewable energy, generator) to operate housing development in case of emergency power shutoff?	Y	By utilizing solar power, we will be able to store our energy onsite through batteries. These batteries will be able to sufficiently power the student housing for several days after blackouts allowing our housing developments to remain operational even in case of blackouts or wildfires
	Please add any additional measures		

Our goal is not only to promote equity within the proposed community, but to provide opportunity to the residents to foster equity as a community within the communities of the Central Valley of California. For too long, the people of Allensworth have lost opportunity when the railroad moved its stop to Alpaugh, neighboring farmers pumped the wells dry, and the lack of protective levies allowed the area to flood.

Creating equitable student housing is crucial for promoting inclusivity and well-being. Accessibility for students with disabilities was ensured by designing the dorms with accessible bathrooms, and walkways compliant with ADA requirements. Moreover, common areas, such as gardens and a community dining hall, were designed to promote socialization and build relationships among students with diverse backgrounds and interests. The dorms were also made environmentally friendly by incorporating sustainable materials and energy-efficient features, creating a healthier living environment. To prepare for potential flooding, the dorm buildings were designed to be raised above potential flooding levels. Additionally, involving an African-American-based building company in the construction process remains true to the original intentions of Allensworth, a city founded to be financed and governed by African Americans. By taking a holistic approach to design, an environment was created that fosters a sense of community, promotes learning and growth, and provides comfortable living space for all students.