
(RE)PRODUCE
Architecture @ Zero 2023

The Problem:

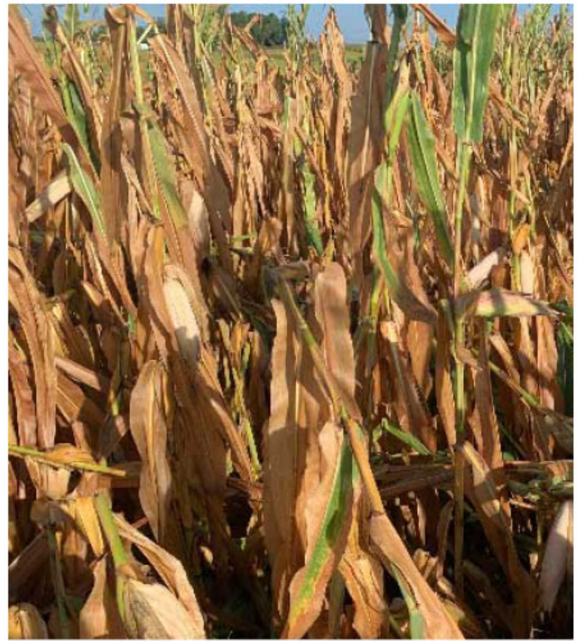
The central valley is the cornerstone of agricultural production in California. The backbone of this abundance is the rural communities whose labor is the first in a long series of steps to get food from farm to table.

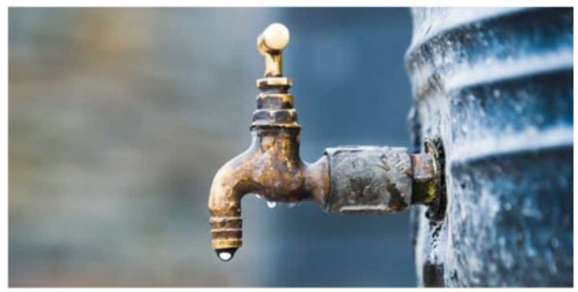
Despite this importance, many of the communities within the Central Valley that are instrumental to California's food production are subject to inequitable conditions due to **water and food insecurity**. Food deserts, Nitrate contamination from fertilizer use, and heavy metals in the water table all work to harm Allensworth and other central valley communities.

These rural communities also bear the brunt of the changing effects of climate and the increase of temperatures, flooding events, and [third] that come with it. Approaches to building in rural communities must avoid **unsustainable building materials and energy generation** in order to be truly replicable at scale.

Though services are present, as seen through the efforts of groups like the Allensworth Progressive Association, small businesses, diverse families, and immigrant farmers continue to fall through the cracks of the public safety net. The effect is a support network that is **brittle and vulnerable** to the continued effects of climate change.

In addition to responding to the competion program brief of 6700sf, the design team seeks to provide a vision that roots the residential and lab space within the larger central valley context.

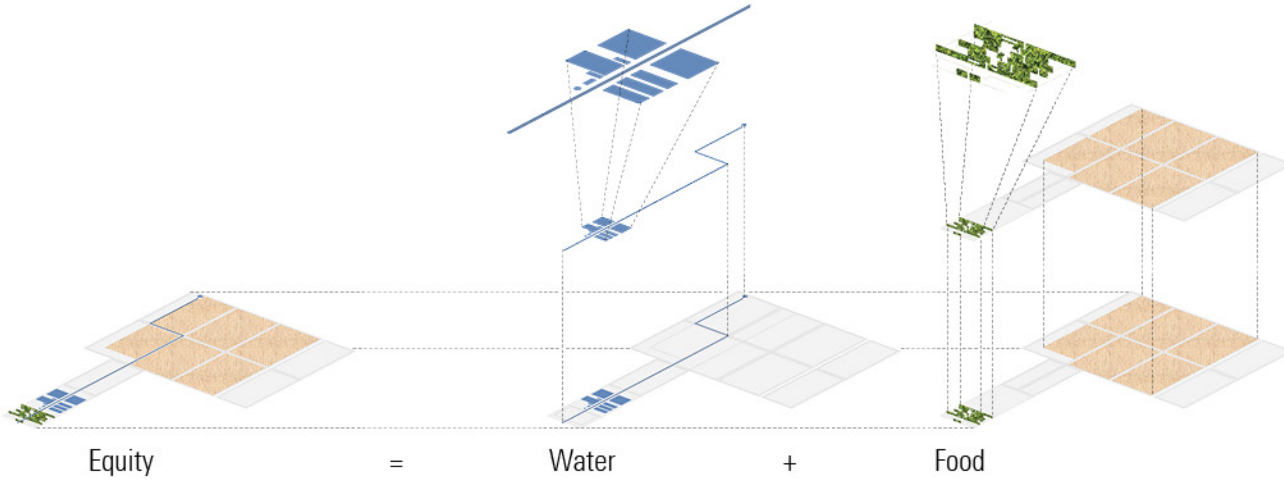




The Solution:

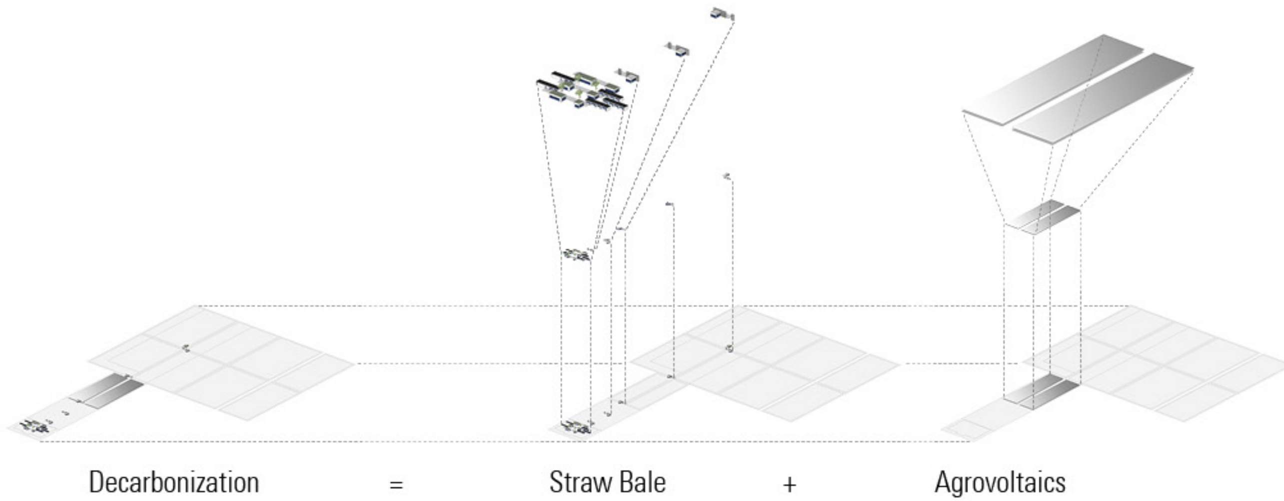
Our solution to these layered problems was to redefine the three prescriptive targets of Equity, Decarbonization, and Resilience as:

Equity = Water & Food
Decarbonization = Straw Bale & Agrivoltaics
Resiliency = Community At Many Scales



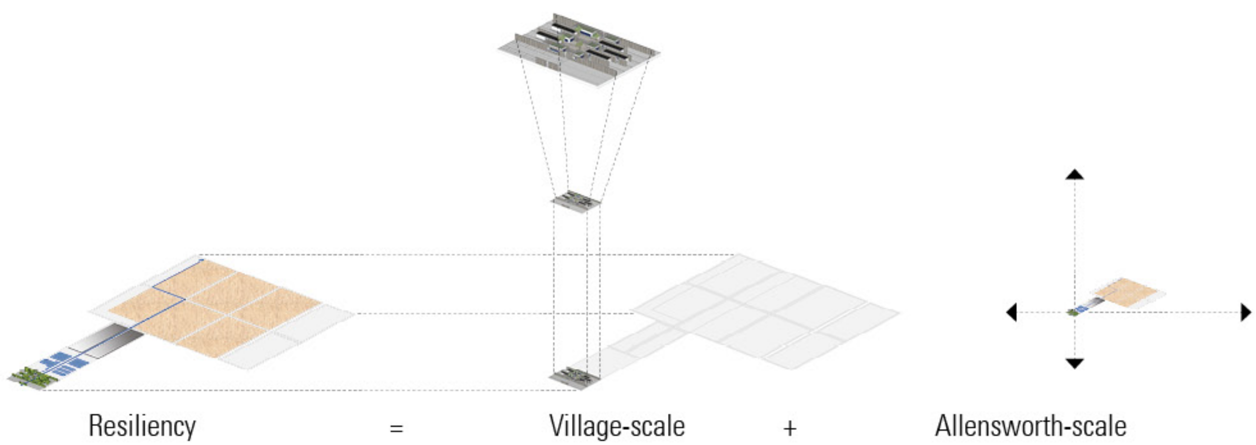
Equity = Water & Food

In order to address food and water insecurity, we see the project as a paradigm for a closed-loop, self-sufficient system that integrates grow walls and water remediation from the on-site well into the architecture itself, putting the power of self-reliance into the hands of the residents of Allensworth.



Decarbonization = Straw Bale & Agrivoltaics

Straw bale, the primary material for our project, is chosen due to its excellent properties that lend itself to an equitable and ecological building. It is a material of the place, affordable without comprising beauty, and an excellent insulator and carbon sink. Our approach to power generation follows these same principles, co-locating solar PV and agriculture through the use of agrivoltaic arrays.



Resiliency = Community At Many Scales

Our goal is the revitalization of Allensworth into a vibrant and resilient community by generating food, water, and power and sharing them with the wider community. The goal is too look beyond the confines of the site to the whole of Allensworth in order to enmesh this prototype village into the broader community.

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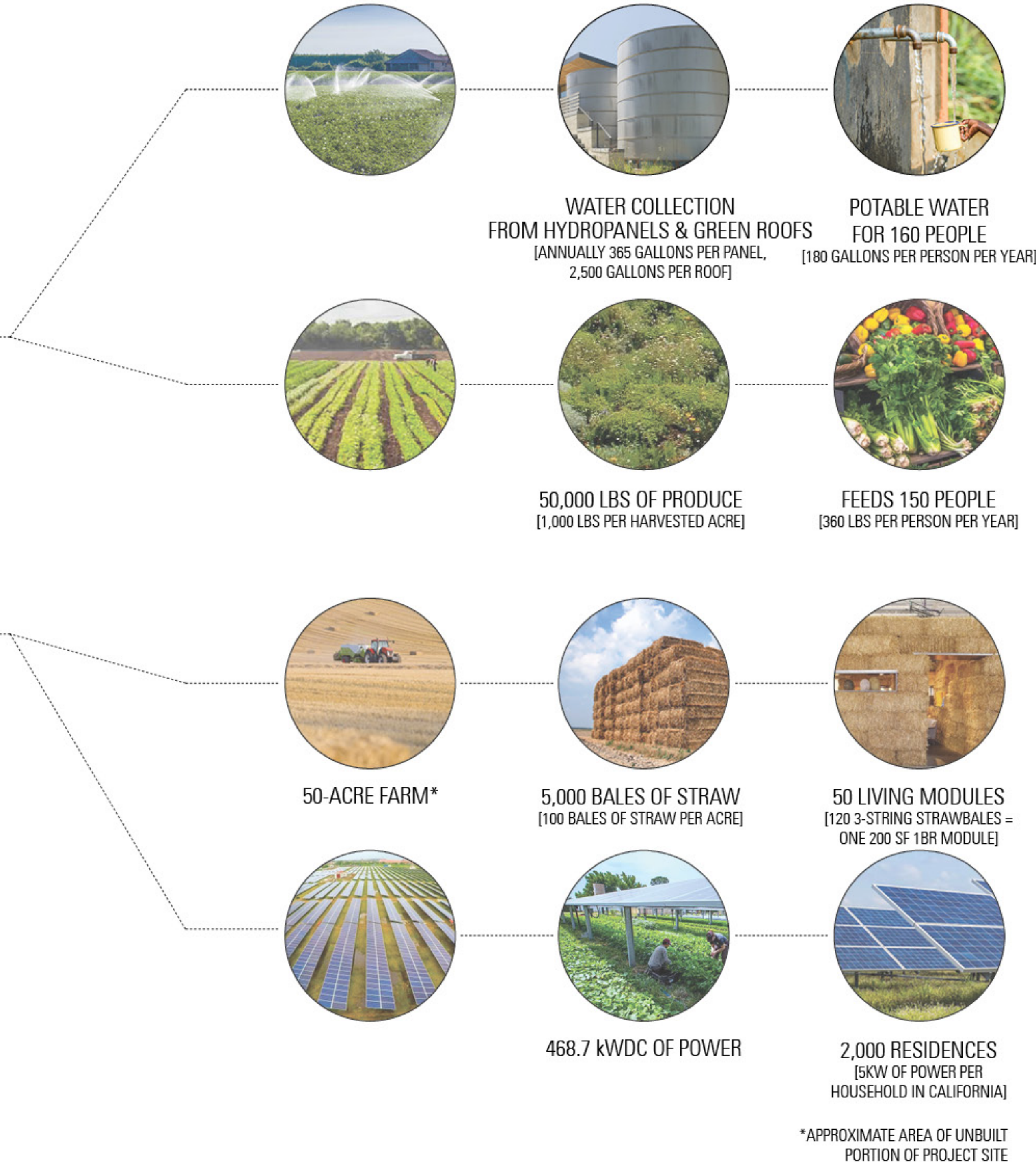

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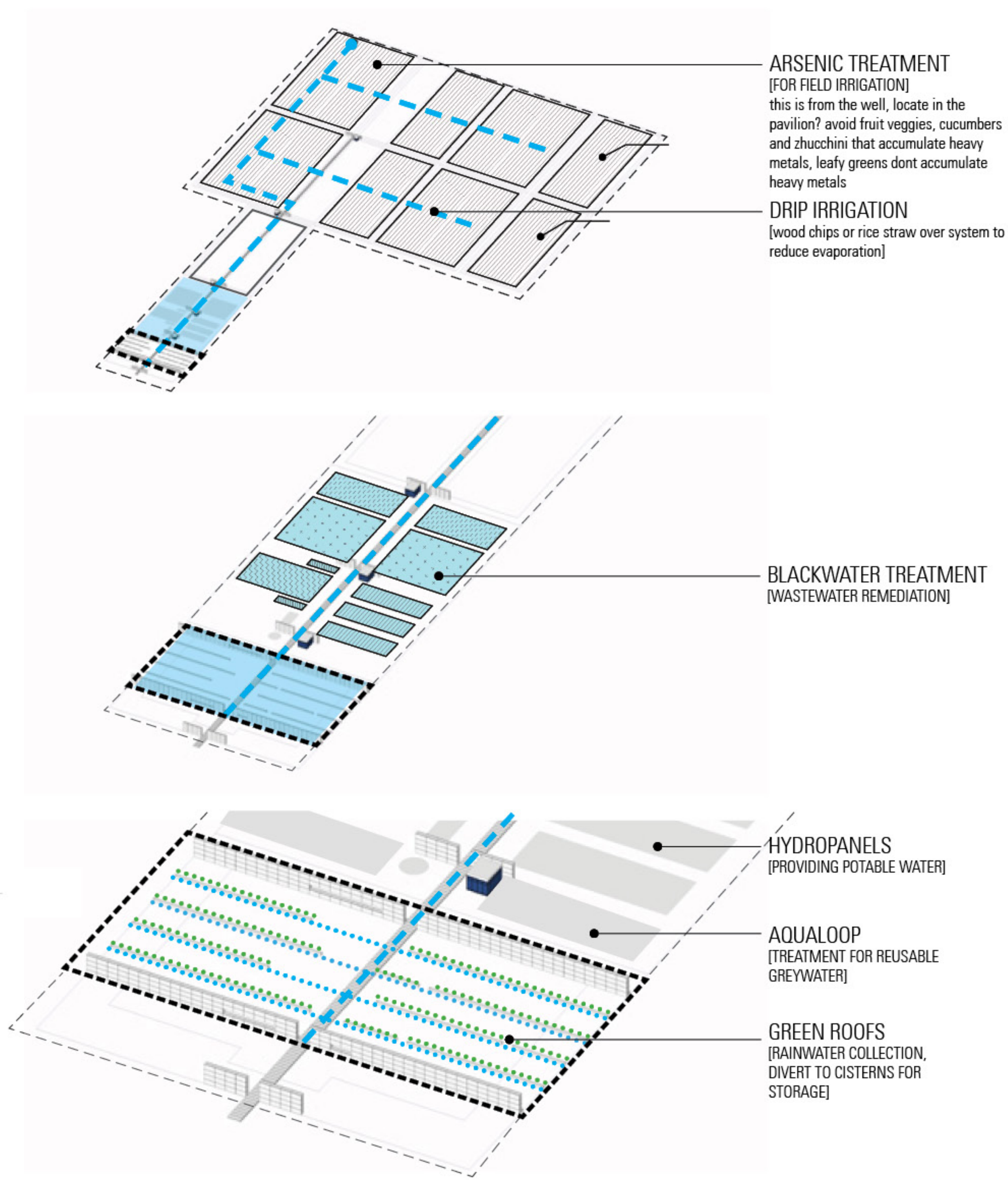

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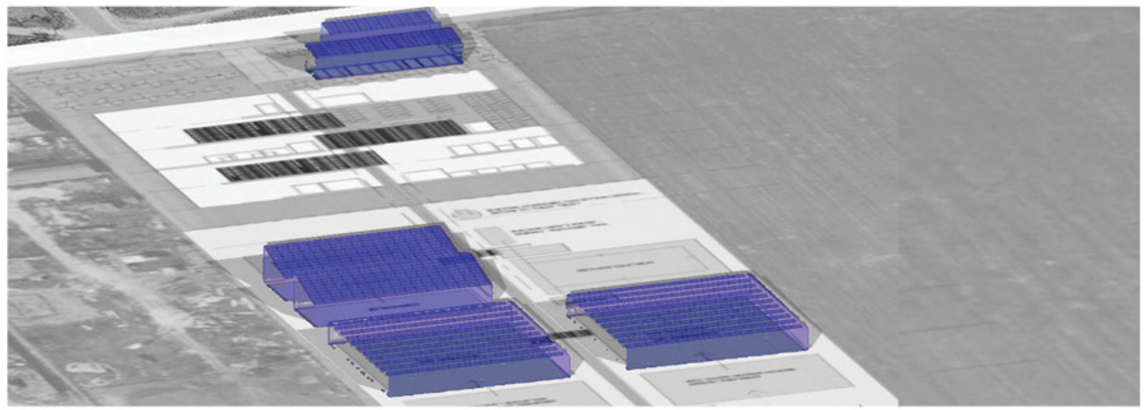
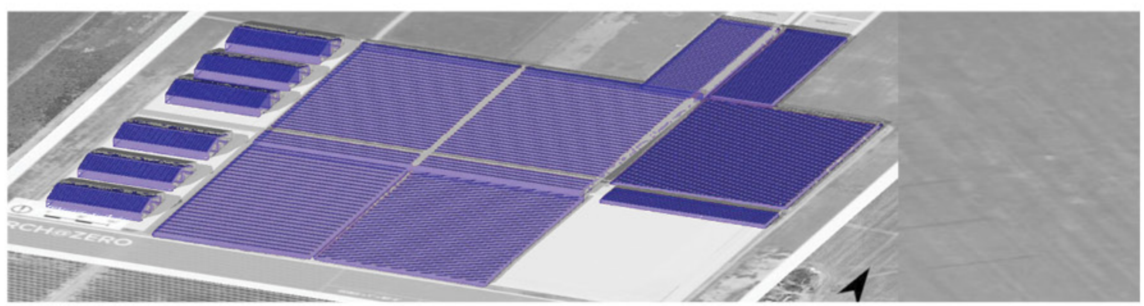
The project will deploy a combined 468.7 kWDC PV system to offset the grid energy use of the buildings and the arsenic water treatment system for potable water. In addition, the project has the potential to deploy more than 10 MW of PV in the form of agrivoltaics and a novel "barn roof". An array of this size would approximately offset the energy use of the entire town of Allensworth more than 17 times over.

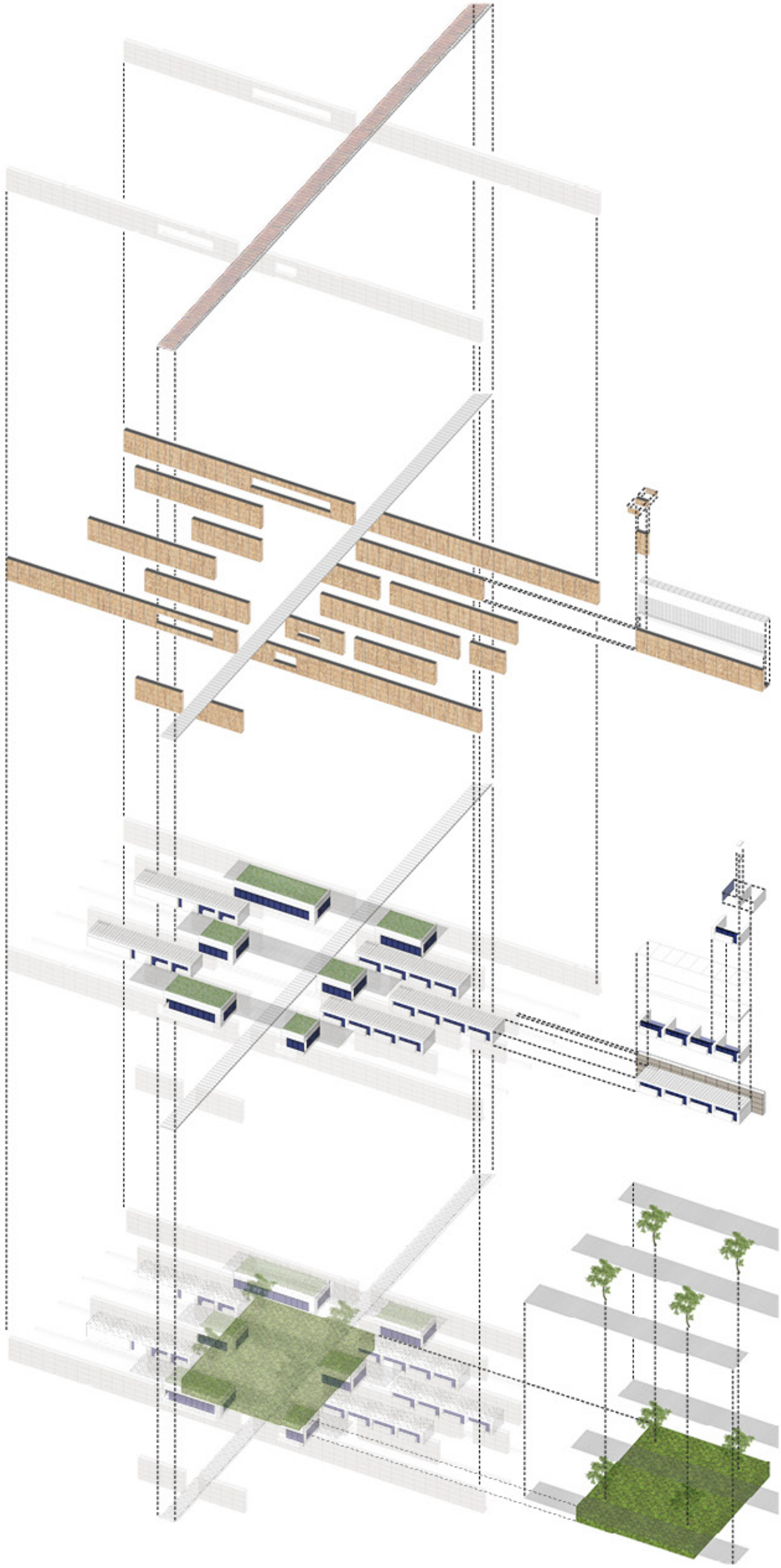
Because of this outsized potential to be a demonstration hub for agrivoltaics, and recognizing the historic injustices Allensworth has faced and overcome, we propose that the 10 MW, always grid connected PV array could be used to fund a "Solar Dividend" to be paid to the households in Allensworth. At the 2021 CPUC procurement rate of $0.026/kWh, this would generate enough revenue to pay each of the ~115 households in Allensworth a stipend of about $350 per month, or $4,500 per year.



468.7 kW Array:



10 MW Array



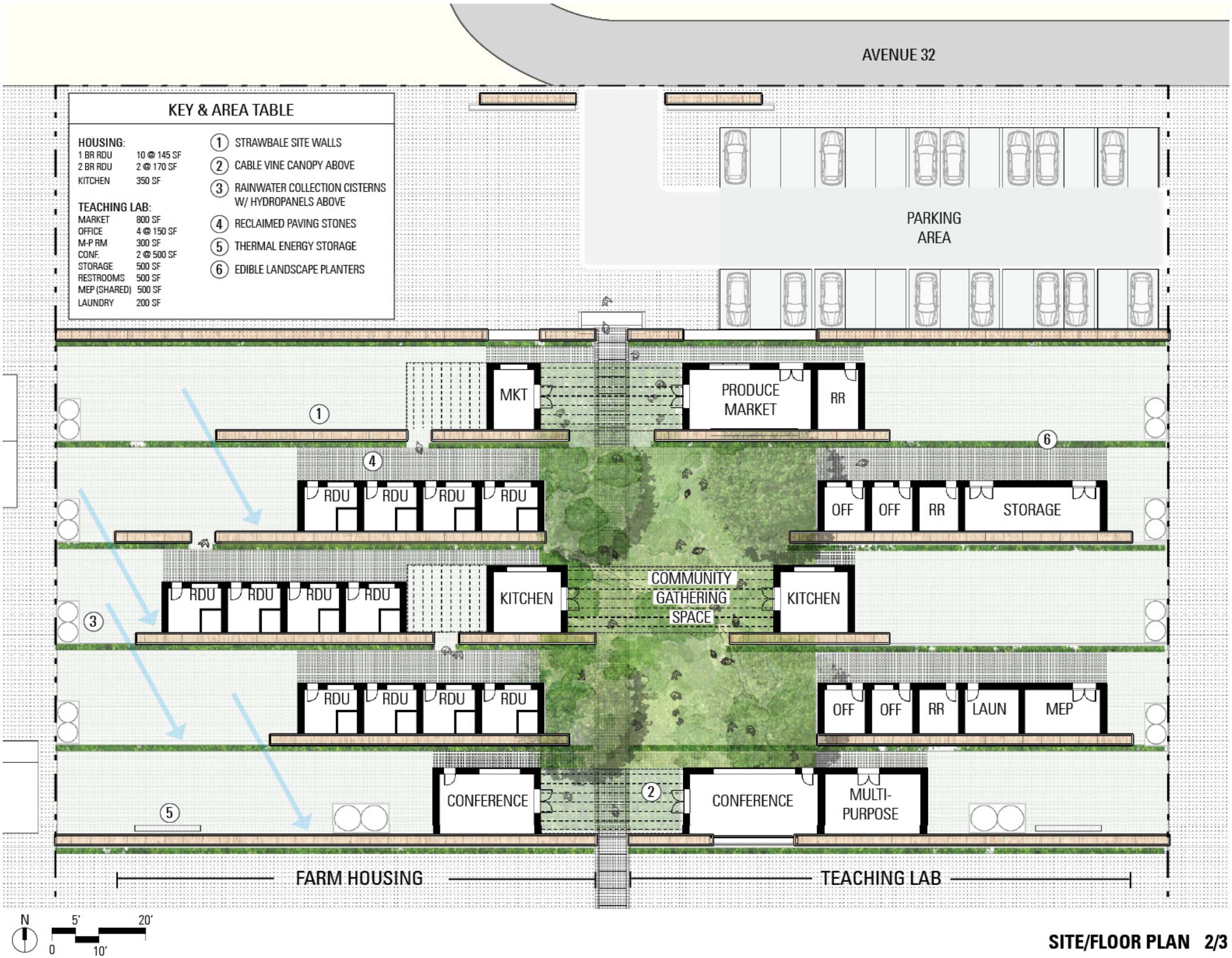
Project Narrative:

SPINE:
The project begins with a north-south path that bisects the site into farm-worker housing on the west and a teaching lab on the eastern half. This spine is a simple desire path, in an effort to tread lightly on the site, while also inviting visitors down to the agricultural and water remediation zones to the south.

STRAW BALE SITE WALLS
A series of east-west-oriented straw bale walls provide a contrasting cadence to the North-South Spine. These walls also serve as a place to grow select fruit and vegetables on their southern faces. In conjunction with the market, this is intended to provide relief to the problem of food deserts within Allensworth. These walls are a post and beam type with a three-string straw bale infill.

STRAW BALE BUILDINGS
On the north sides of these walls are the housing and lab spaces, constructed of two-string load bearing straw bale walls. On selected buildings, we combine energy technologies (solar roof tiles, chiller, and thermal energy storage systems) with a limited kit-of-parts assembly, producing a series of building modules that are both efficient and easy to replicate.

HEART
At select locations, the site walls are pulled back in order to connect the public, tech lab, and shared kitchens on either side of the program areas. This third space, different that the growing spaces on the southern faces of the walls, and the programmed spaces on the north, serves as the center of the community, linking the two halves together in a public space that forms the heart of the scheme.



SITE/FLOOR PLAN 2/3

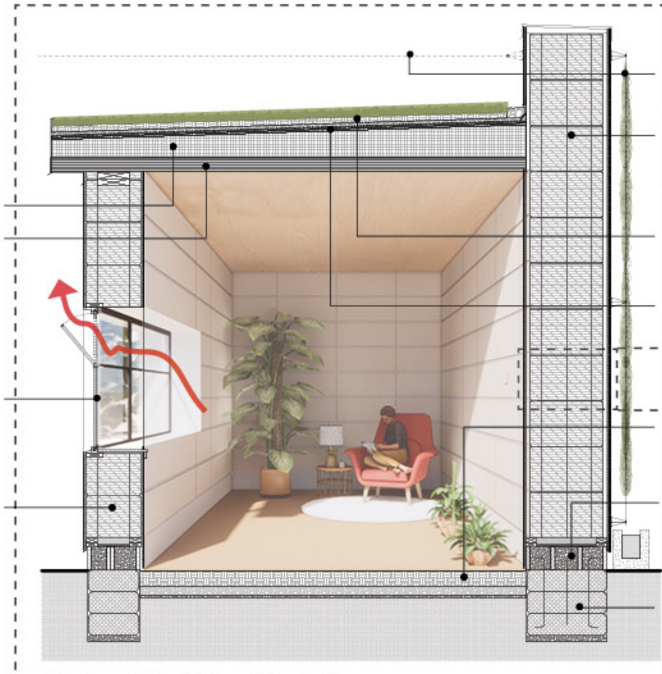
The carbon sequestered by the strawbale walls and MPP roofs is equivalent to taking 34 cars off the road and carbon sequestered by 180 acres of US forests each year:

This is equivalent to Carbon emissions from:

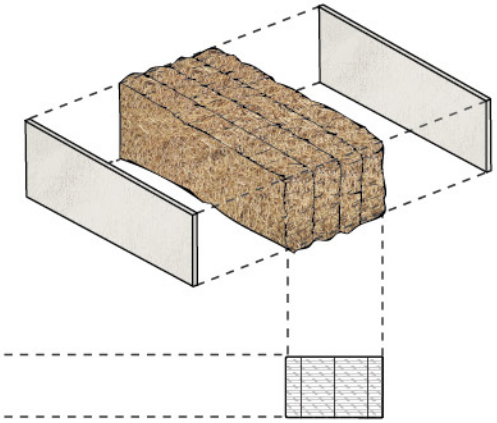
34
gasoline-powered passenger vehicles driven for one year

This is equivalent to Carbon sequestered by:

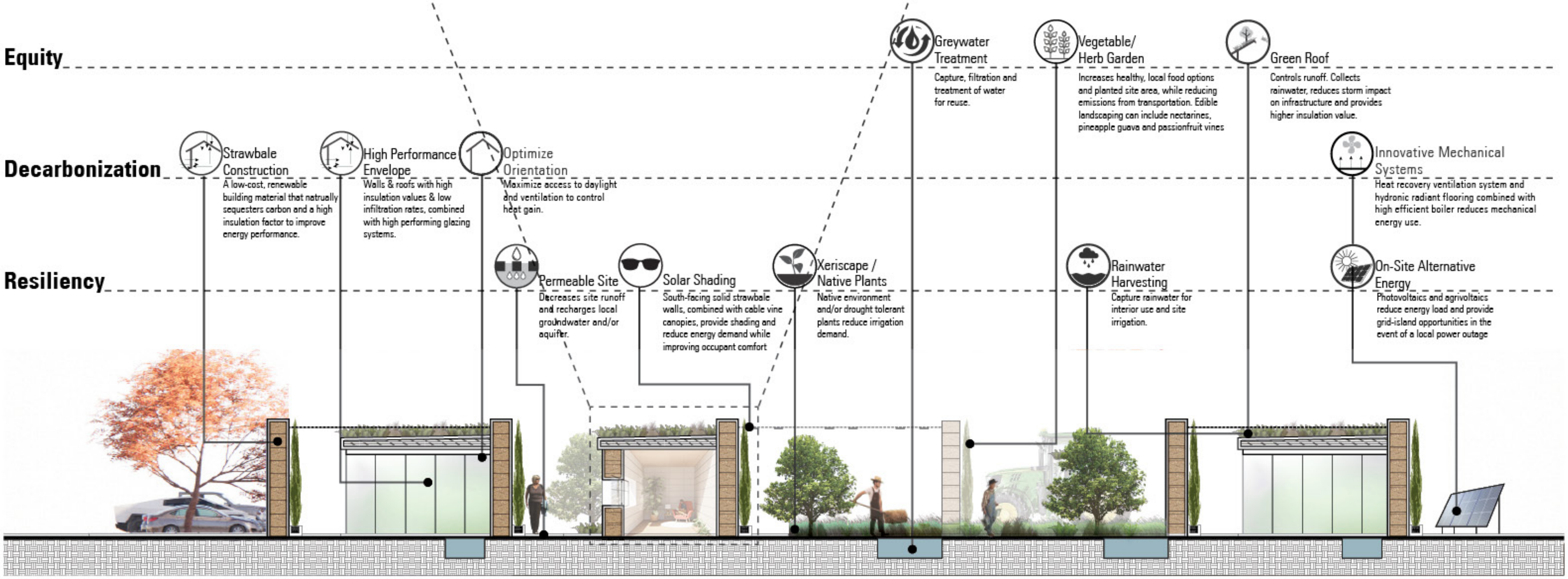
180
acres of US forests in one year



Typical Building Module



Strawbale Detail



Aerial View, Looking South. All buildings are situated on the Northern side of the large strawbale construction site walls and open up to the central gathering space.

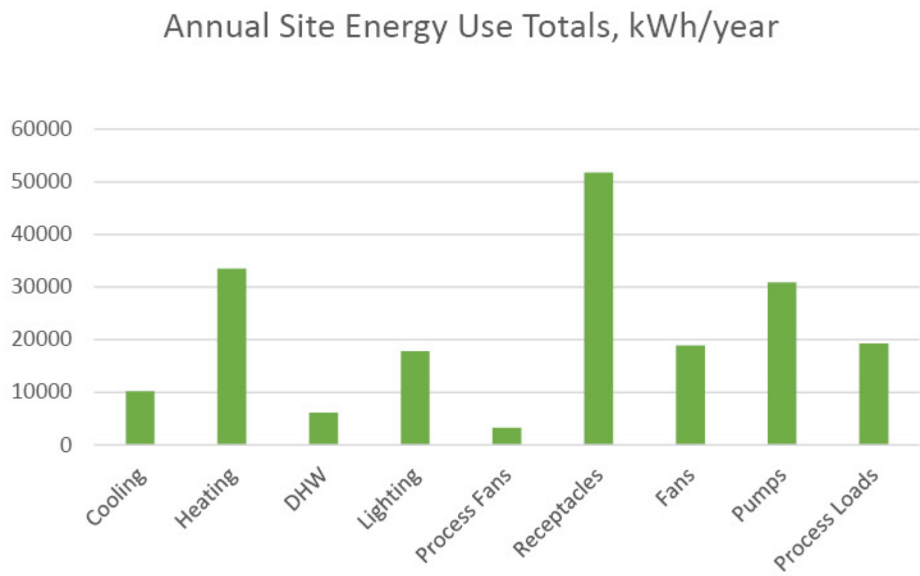
Aerial View, Looking North. Green walls are placed along the Southern side of the large strawbale site walls and act as backdrops to all the buildings facing out to them.

PERSPECTIVE 4A

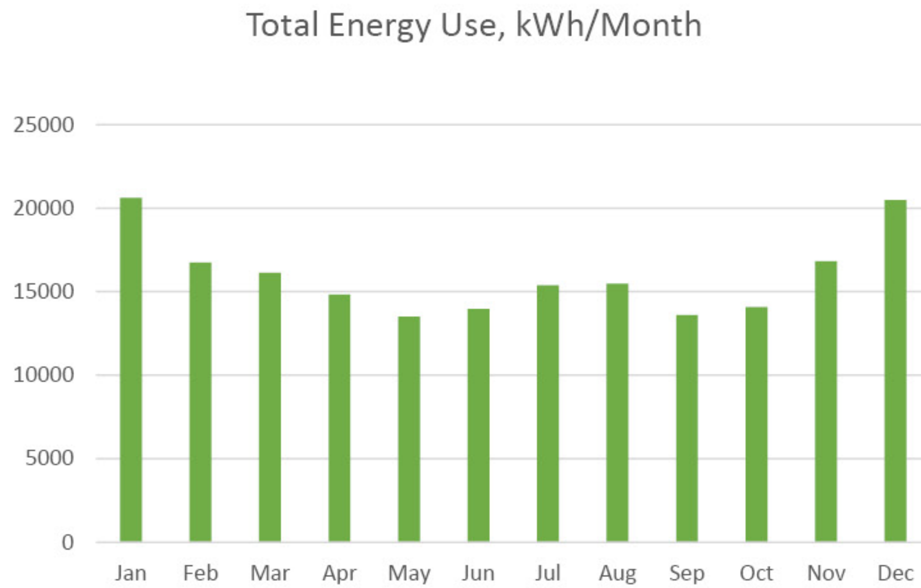
Eye level view of central community space, partially framed by the staggered strawbale site walls.

Buildings are North of the walls and open up to the communal space;
Green walls are South of the walls and act as backdrops to daily life.

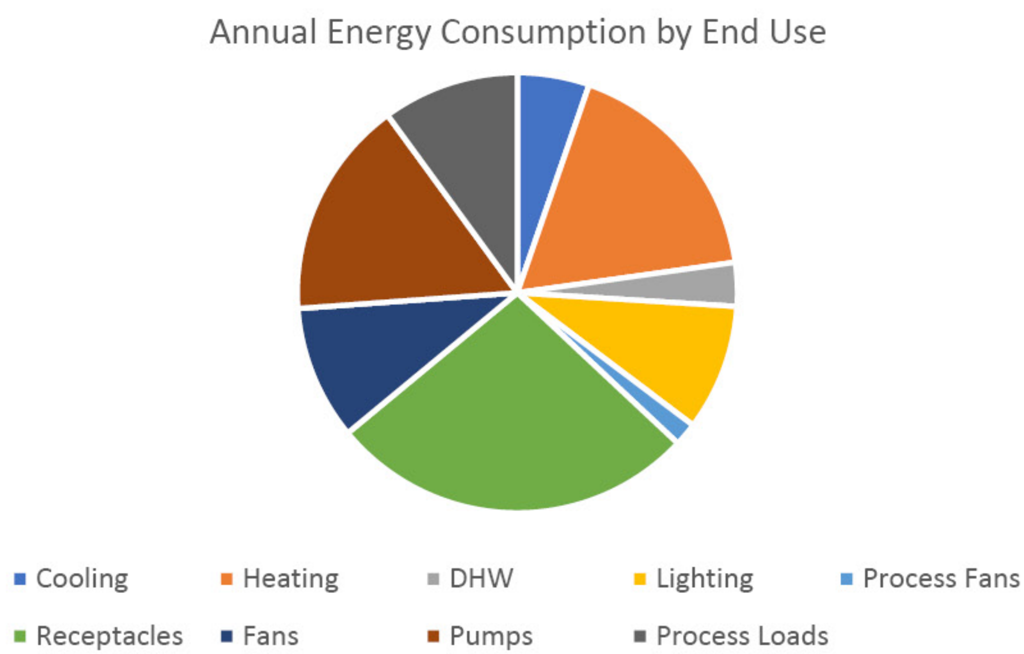
Type	System Details
Heating System	10 HSPF Mitsubishi Air Source Heat Pump, Ducted
DHW System and Cooling System	Combined Air-source R32 chiller and heat pump water heating system, 65 tons, Providing Central A/C and Water heating as a form of Thermal Energy Storage, COP 5.0, Net SEER 18.5
Ventilation System	Manually operable ventilation windows, Bathroom and kitchen fan efficacy testing, fresh air ventilation from ducted heating/cooling system
Indoor / Outdoor Lighting	100% LED (200 lm/W) With vacancy control and dimming
Renewable PV Generation	468.7 kW Canopy and Agrivoltaic PV Array
Energy Storage System	LiFePo 274 kWh, with a 43-kW inverter

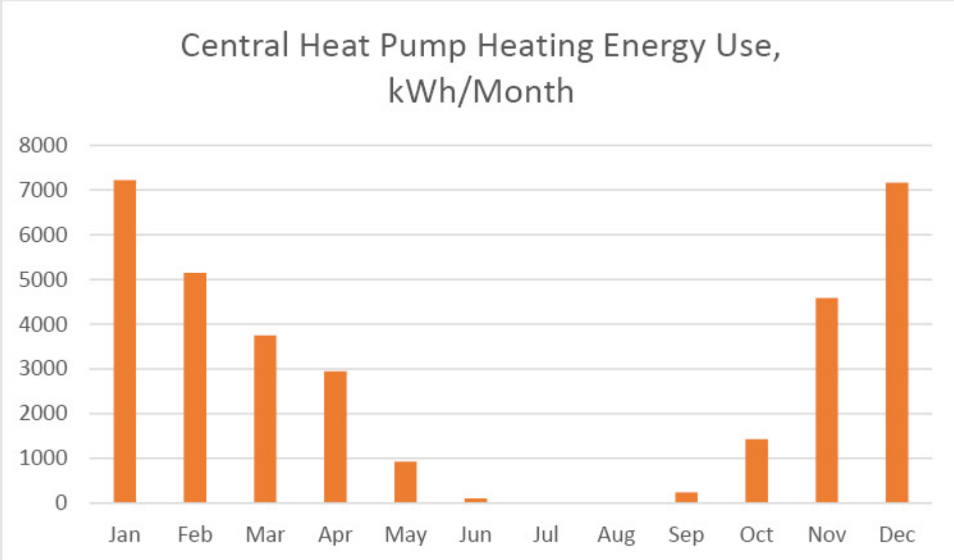


By far the largest load at the site is Receptacles, which includes many end uses from residents' personal devices to refrigerators and office equipment. The next highest is heating, which is in part thanks to our TES strategy of combining DHW and Cooling equipment. Pump energy use is much higher than typical, accounting for the use of arsenic treatment equipment, Aqualoop greywater recycling, and the well pump.

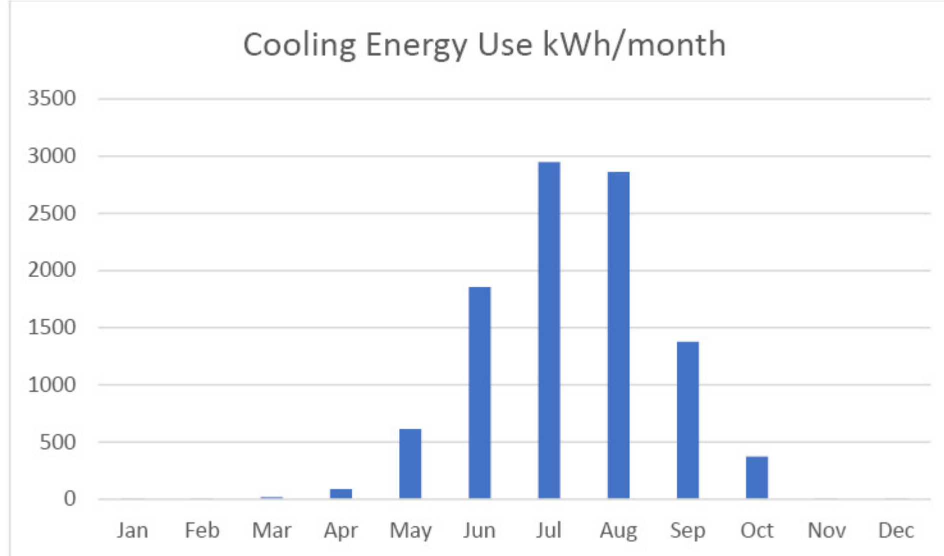


Typical of an all-electric development, winter is the season we see the highest energy use. There is a small bump due to hot summers in July and August, which is partially reduced by the TES chiller strategy.

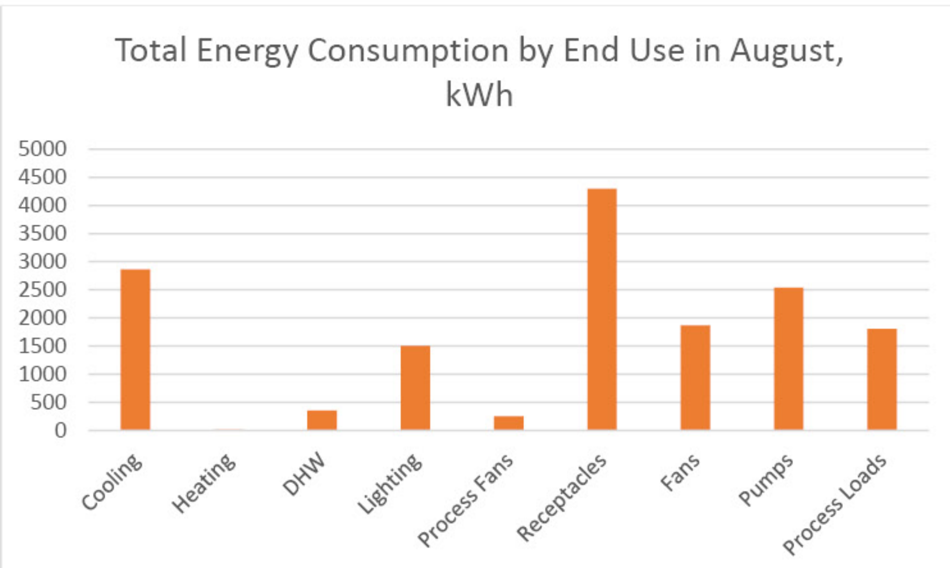




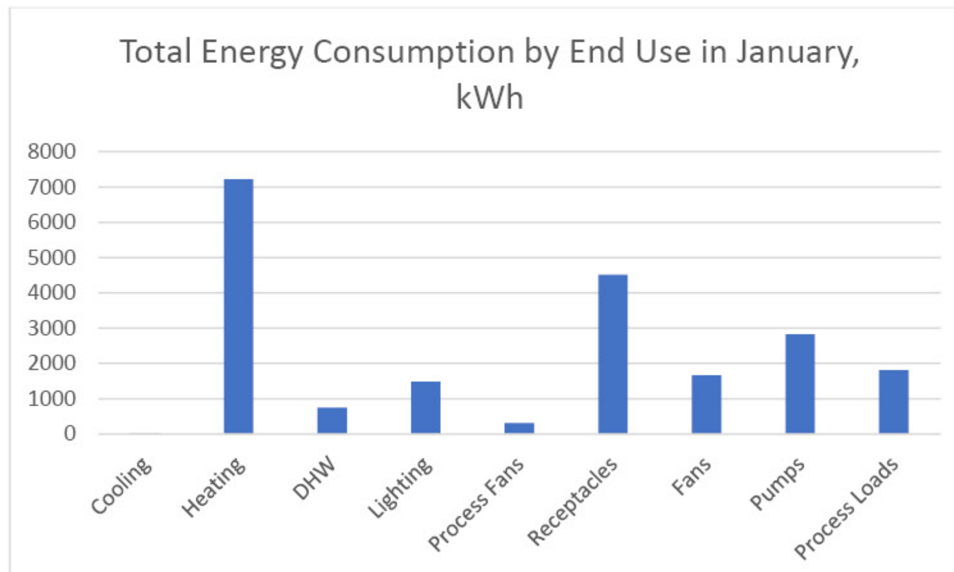
Heating is notably high over the year because of the relatively cool and long "Tule Fog" season in the area, stretching from November to April, with little to no shoulder seasons. In an all-electric future, we will see peak grid usage periods occurring in January due to heat pump heating loads, which is a part of why this solar array is oversized – to anticipate future needs of the community and California as a whole.

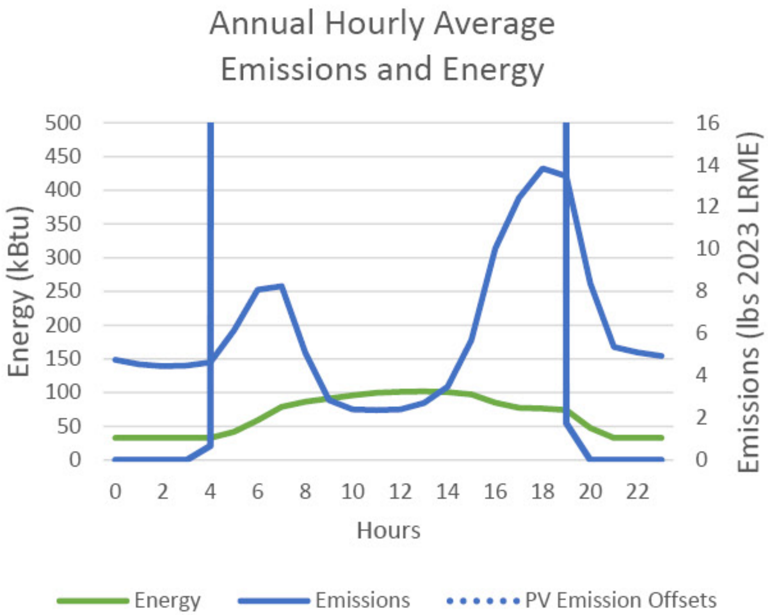


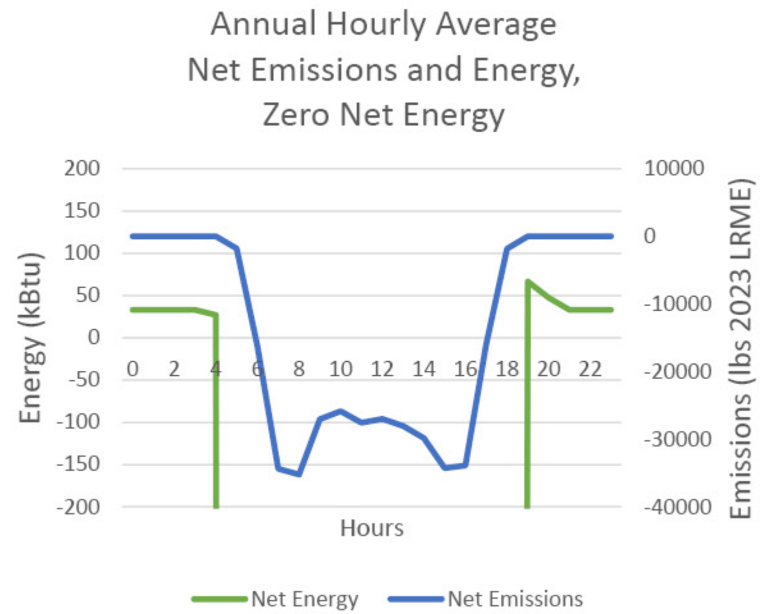
The cooling season is relatively shorter, and the chiller is working highly efficiently. Summers in Allensworth have cool nights that allow for natural ventilation-based cooling to mitigate the internal heat gains of the buildings as well and allow for pre-cooling in the mornings.



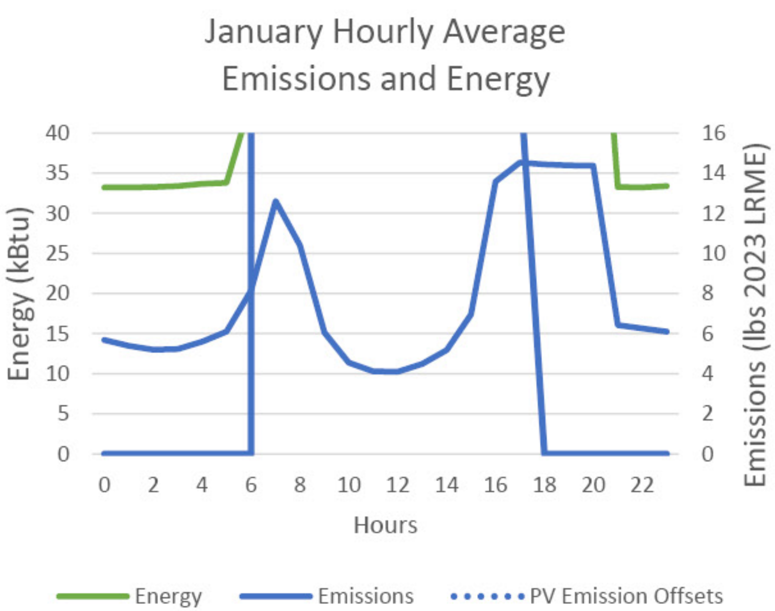
In August, our relatively stable Receptacle load is now the largest load at the site. The dispatchability of the receptacle loads makes managing them a crucial component of the battery storage system for resilience. We can extend the useable hours of a battery storage system by turning off circuits that aren't desirable for resilience purposes.

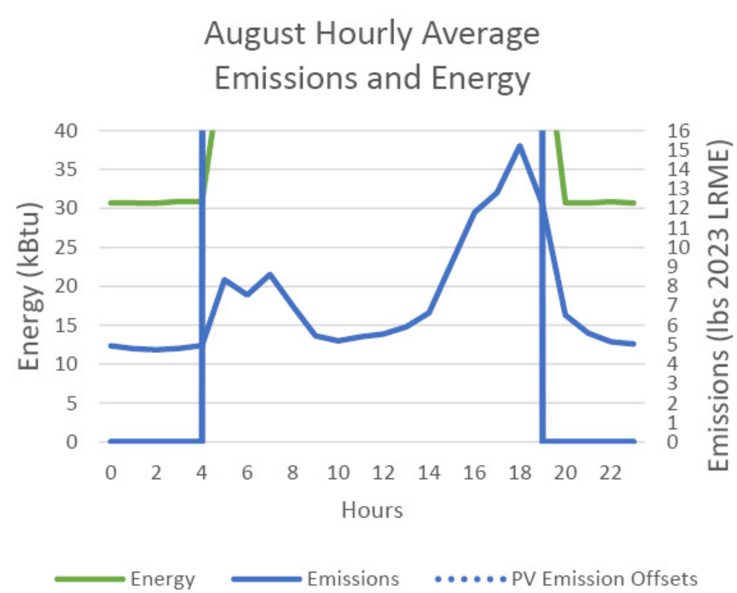






This project is well in excess of being Zero Net Energy, meaning the project produces more energy than it pulls from the grid on an annual basis. Because this project is going to far exceed Zero Net Energy, some of the emissions metrics are asymptotic because the net emissions at those hours of the day are zero.





Renewable Systems - Grid & Economic Security

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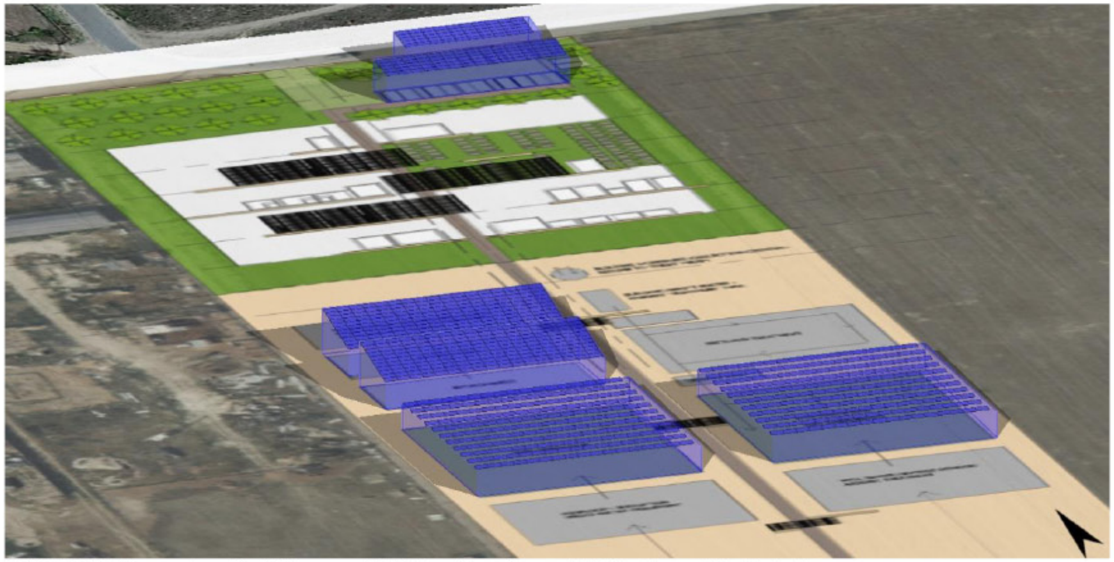
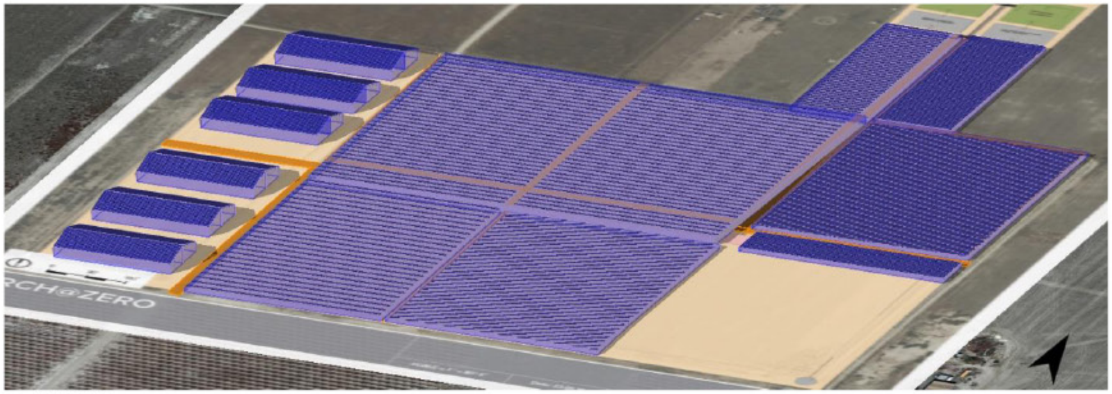


468.7 kW Array for Building and Water Treatment Offset and Grid Autonomy



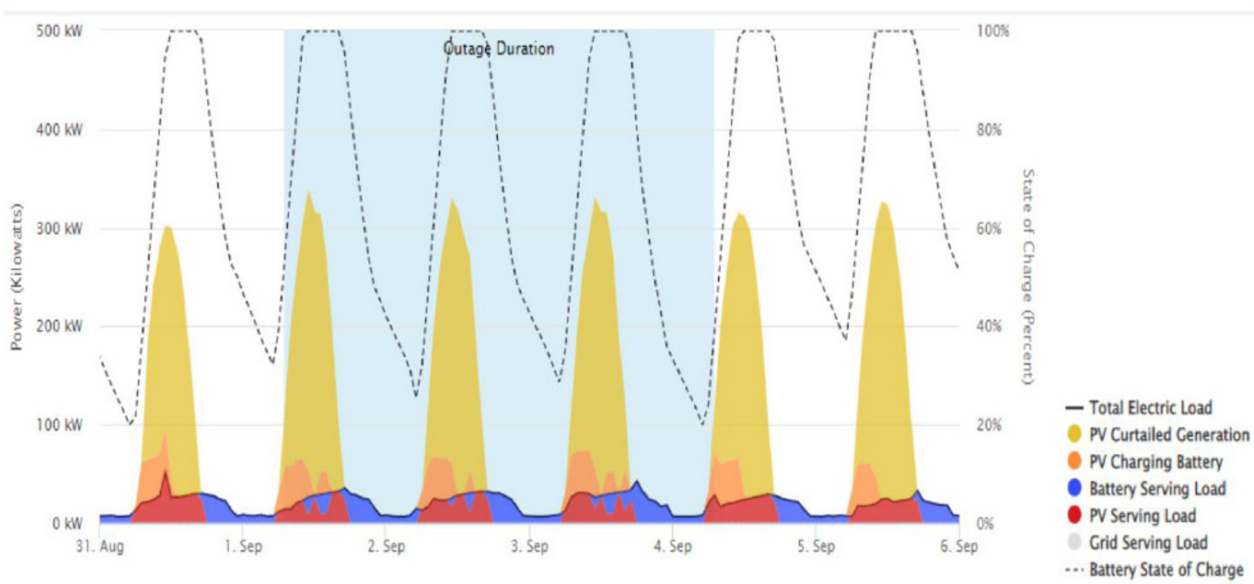
10 MW Array

Storage Systems

Allensworth is vulnerable to grid outages, especially during the hottest parts of the year and during wildfire season. There is an opportunity to use the 468.7 kW of main site solar to make the farm lab, produce market, multipurpose room, and student housing semi-grid autonomous. Using a combination of Agrivoltaics and traditional canopy PV arrays, the site achieves grid autonomy for at least 72 hours during an outage at typical operating capacity. The battery system would be grid tied and capable of islanding, allowing for grid servicing with the capacity to react to grid events to create a resilience hub for the Allensworth community. This allows the (Re)Production site to help reduce California's grid carbon emissions and provide treated water to Allensworth residents even when the grid goes down.

The battery design for (Re)Production is **274 kWh**, with a **43-kW** inverter. With this system, (Re)Production is able to avoid **91%** of lifetime grid carbon emissions as compared to the business-as-usual case by avoiding grid energy usage. The site's energy use is only estimated to contribute 189 tons of carbon to the atmosphere via grid emissions over 25 years.

Because of the high PV capacity at the site, we are able to operate as a grid-island during the critical load period for 72 hours with a small microgrid. Islanding can be extended further via a selective loads electrical panel that can isolate only the circuits that the site manager identifies as crucial loads. The arsenic treatment for potable drinking water for the community can potentially be kept online indefinitely if all other circuits are curtailed.



Load Profile Simulating a Power Safety Shut-Off Event (72-Hr)

Decarbonization Narrative:

Our team is committed to delivering an exemplary low carbon and resilient project for the town of Allensworth. The project will serve as a leading-edge example of a sustainable project that embodies the environmental priorities of the local and regional community. The design focuses on strategies that reduce consumption of valuable resources while creating healthy, functional, resilient and equitable spaces for residents and neighbors.

The project has aggressive goals to reduce holistic greenhouse gas emissions, to reduce embodied carbon from building materials, and achieving operational carbon reductions through electrification, efficiency measures and on-site renewable energy. The project will serve as a low carbon model not just for Allensworth but for the entire state by eliminating fossil fuel use for space heating, domestic hot water, kitchen, and all farming activities. Electrification reduces the project's carbon footprint while preventing harmful emissions from being released indoors and outside.

Passive strategies used include 24" thick strawbale exterior walls providing a high R value (R-30) and a green roof that reduces heat gain and increases thermal comfort for residents. The green roof also prevents heat island effect while providing additional benefits including providing a pollinator habitat and contributing to storm water management. A high performance heat pump HVAC system, a centralized heat pump water heater and LED lights reduce energy consumption. The HVAC mechanical system also includes a water based Thermal Energy Storage system (TES), which stores energy during off peak hours and uses it for cooling during peak hours. The project also incorporates combination washer/condenser dryers with ventless heat pump technology which utilize (50%) less energy than typical dryers.

A waste water energy capture system will be installed to extract and transfer heat to/from waste water to supplement the space heating and cooling needs as well as pre-heating the hot water, to save energy and ghg emissions.

Renewable energy is generated with site photovoltaics and agrivoltaics which make this a net positive energy project. The agrivoltaics on the "neck" of the site provide enough power needed for the buildings on site, (approximately 60kW peak power). If the entire area of the farm is used for agrivoltaics, an additional 10 MW can be produced which could be used to power the entire town of Allensworth. Any unused power could be returned back to the grid and residents could get a pay back in the form of a solar dividend (approximately $350 per month per household based on the 2021 CPUC procurement rate). In conjunction with the photovoltaic systems, bi-directional EV charging is provided at the parking area to provide power to electric trucks and tractors and to act as back-up power as part of the project resiliency plan.

The design emphasizes low embodied carbon for new construction by using 2-string and 3-string strawbale walls, mass timber roof and repurposed rubber tire foundations filled with low carbon concrete as the primary load-bearing structural system. Strawbale is a natural material which stores carbon like any plant based material through photosynthesis. Given that an 8x4 panel of 2" thk strawbale stores about 0.078 metric tons of CO_2e, our building walls will sequester about 69 metric tons of CO_2e. The MPP (mass timber) roofs will sequester 82 metric tons of CO_2e. Combined, this is equivalent to carbon sequestered by 180 acres of US forests in one year or taking 34 cars off the road for a year (per EPA's Greenhouse Gas Equivalency Calculator). The building interiors also use low carbon materials including wood windows, clay plaster over strawbale walls and Insitu earthen floors.

PROJECT NAME:	(Re)Production		
IMPACT	**ADAPTIVE MEASURE**	**USING THIS MEASURE? (Y/N)**	**IF THE PROJECT IS EMPLOYING THIS MEASURE, BRIEFLY DESCRIBE TECHNICAL SPECIFICATIONS**
HEAT	Is the project planting trees that will provide shade to buildings, homes, sidewalks, streets, or parking lots?	Y	Trellis structures on buildings will allow
	Is the project enhancing insulation of homes?	Y	Straw bale construction utilizing wall assemblies greater than or equal to R30, ceiling insulation of R60 with blown-in cellulose
	Is the project installing cool roofs?	Y	Sedum green roof provides cool roof benefit.
	Is the project reducing electrical grid demand and household costs associated with cooling?	Y	Entirely off-grid project, also utilizing a combined cooling-DHW chiller system that pulls heat from the building to be stored as hot water, raising the net efficiency of the cooling loads while also reducing energy use in the DHW system. An Air-source heat pump will provide heating in the winter.
	Is the project providing a community cooling center?	Y	Multipurpose Room will serve as a resilient cooling center, whole site will be able to go off-grid with PV and Batteries for 3+ days in both winter and summer.
	Is the project adding permeable land cover?	Y	Native grass lawns with a 50% Miniclover seed mix for water retention, nitrogen fixation, and root structure.
	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	
	Please add any additional measures employed to address this impact.		Native grass lawns with a 50% Miniclover seed mix for water retention, nitrogen fixation, and root structure.
PRECIPITATION CHANGE *(e.g. drought, extreme precipitation events)*	Is the project setting up an ongoing mechanism to conserve water?	Y	Rainwater cisterns are incorporated into all buildings' plumbing infrastructure (~30,000 gal/year), Aqualoop greywater treatment system will recycle greywater for use in landscaping irrigation (263,000 gal/day). HydroPanel air-source water collection systems will provide clean drinking water from the atmosphere for 24-person occupancy all year long, with surplus water stored in cisterns for resiliency and community support.
	Is the project promoting improved soil health, soil quality, or soil stability?	Y	Turf mixure will provide nitrogen fixation and root structure for grassy areas, Agrivoltaic system designed to allow for crop rotations and testing of different shading levels of crops to promote soil health.
	Is the project restoring wetlands, watersheds, or riparian buffers?	Y	Wetland area onsite being restored with treated greywater to supplement the natural rainfall and to simulate the historical water storage pattern that would have been available from the Lake Tulare basin if not for commercial agricultural irrigation practices.
	Is the project planting native, drought-tolerant vegetation?	Y	Food bearing trees and landscaping vegetation will be planted that are also trought tolerant and appropriate for the south San Joaquin Velley, including Dragonfruit, Meiwa Kumquat, Passionfruit, Pineapple Guava, and Arctic Queen Nectarines.
	Is the project changing permeable surfaces to paved surfaces?*(Negative co-benefit.)*	N	
	Is the project increasing water use? Negative co-benefit.	N	
	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?	N	
	Does the project involve rehabilitation work in a high priority landscape impacted by wildfire?	N	
	Does the project involve fire hazard prevention work to mitigate wildfire threats to communities?	Y	Straw Bale construction is highly fire resistant due to the plaster exterior. In addition, a green roof and lack of an attic will reduce the risk of structure fires being caused by wildfires.
	Is the project implementing other types of forest or other ecosystem management treatments to reduce wildfire intensity or reduce potential impacts of wildfires?	N	
	Is the project implementing other fire mitigation or prevention measures for non-forested habitats that may be impacted by wildfire?	Y	Recycled greywater for landscape irrigation will keep vegetated areas green, reducing the capacity for fire spread on the property.
	Does the project involve new construction in a high priority landscape for reducing or preventing wildfire threats? *(Negative co-benefit.)*	N	
	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	72-hour rated islanding combined PV and battery storage system.
	Please add any additional measures employed to address this impact.		Extensive rainwater catchment at the buildings reduces the risk associated with lost water access due to fire damage to water infrastructure at the well or well pump.

Water Management Strategies

As the climate shifts, the need for efficient and innovative water management strategies is growing increasingly apparent for building and sustaining self-reliant, climate-resilient communities. Located in the arid heart of California's Central Valley and in a town with a long history of facing water-related challenges, the Allensworth teaching and innovation farm presents a unique opportunity to demonstrate such strategies.

Our proposed water management scheme for the Allensworth project consists of the following elements: greywater treatment and reuse, rainwater collection, air-source water collection, treatment of contaminated well water, and water-efficient edible landscaping.

Drought-tolerant and Edible Landscaping
Incorporating drought tolerant landscaping, as well as edible landscaping with low water requirements, benefits the Allensworth demonstration farm in two ways: (1) reducing the total amount of water needed to irrigate the landscape and improving the efficiency of water use at the site, and (2) demonstrating to visitors of the site that using less thirsty landscaping can still provide edible, nutritious products. Examples of edible landscaping choices include Arctic Queen Nectarines, Dragon Fruit, Meiwa Kumquat, Pineapple Guava, and Passionfruit.

Greywater collection
All greywater produced in the buildings at the site will be collected and treated using an Aqualoop water treatment system. The Aqualoop system is capable of producing irrigation-quality treated water for non-potable use (verify standard). Using the Aqualoop system, greywater will be reclaimed for drought-tolerant and edible landscaping irrigation. The team proposes two Aqualoop systems be installed at the site – a smaller system on the east side to collect sink water from the farm lab, and a larger system on the west side to collect the larger greywater load from the housing buildings. Based on a greywater production of 30 gallons per person per day, an estimated 720 gallons per day of reclaimed water can be produced using the Aqualoop. Treated water can then be used to irrigate the drought-tolerant and edible landscaping around the built area of the project site. Although irrigating the farmland using reclaimed greywater would be ideal for improving water efficiency at the site, it has been determined that the volume of reclaimed water produced by the greywater treatment system would be insufficient for irrigating the cropland.

Rainwater Catchment and Storage
The team proposes that a rainwater catchment and storage system be incorporated into the design. Rainwater alone will not be sufficient to satisfy the water use demands at the site. The team proposes that rainwater collection be designed for the site to boost the site's resilience to power outages, wildfires, or other climate-related events. Rainwater will be collected from green building roofs and filtered into cistern(s) adjacent to each building with rainwater catchment. (Size of rainwater cistern).

Hydro Panel Air-Source Water Collection
SOURCE HydroPanel technology allows for the collection of potable water from ambient moisture in the air. The design incorporates ten hydropanel units. Water collected from the Hydropanels will be combined with rainwater in the collection cisterns.

Irrigation Water Treatment
The town's arsenic-contaminated water supply further necessitates an innovative water management strategy. The site utilizes the CalBerkely Arsenic Treatment developed by the Gadgil Lab for Energy and Water Research, in order to reduce the harmful levels of arsenic below the EPA reccomended limit.

Equity Narrative:

Inequity in design is comprised of a multitude of components, from the historical, environmental and cultural. Our proposal seeks to contend with the history of Allensworth as California's first intentional Black community, as well as the contemporary fact that it is now 95% Hispanic.

To that end, we identified three through-lines that weave through the different cultures and time periods of Allensworth. These are **Self-Reliance, Community and Quality, and Education**.

Historic Equity - Self-Reliance

The core of the question of equity was the issue of water; The historical denial of water rights, the contemporary effects of that denial, and the necessity to reach back to the founding principles of the town in order to build a better future. The project is designed as a closed-loop village that reclaims its own greywater, grows it's own food, and produces it's own power - all while extending these resources to Allensworth, integrating it into the community.

Enivronmental Equity - Community and Quality

Our material choice lends itself to environmental equity, both in regards to the inherent quality of straw bale as a healthy, sustainable and long lasting material, and the positive effect that load bearing straw bale construction has on communities. Straw bale lends itself to community building in the form of approachable barn-raising events that the whole of Allensworth can take part in.

Education

One of the founding values of Allensworth is education, as seen through the largest capital investment made by the community in 1912, The Allensworth School, and by Cornell Allensworth dream to see the town as the "Tuskegee of the West". We envision the tech lab not only as a place for students to learn about vermiculture and regenerative farming but also as the remediation and conservation of an at-risk resource in the central valley: Water.