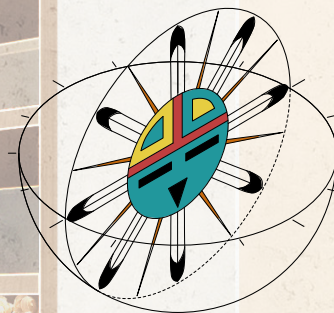


HARVEST MESA



Net-Zero Condominiums for the Hopi Tribe

SDDC 2024 | UA Team 2 | Attached Housing



College of Architecture,
Planning & Landscape
Architecture

TAWA'OVI TEAM / The University of Arizona



[UA ATTACHED HOUSING TEAM / solar decathlon 2024]



Jedidiah Perea [TL]
Albuquerque, New Mexico
B.ARCH 2025



Jordan West
Gilroy, California
B.ARCH 2025



Pablo Cabanillas
Tucson, Arizona
B.ARCH 2025

[CABANILLAS . MOODAY . NELSON . PEREA . WEST]



Emme Mooday
Los Alamos, New Mexico
B.ARCH 2025



Olivia Nelson
Austin, Texas
B.ARCH 2025

PROJECT / introduction



[UJA ATTACHED HOUSING TEAM / solar decathlon 2024]



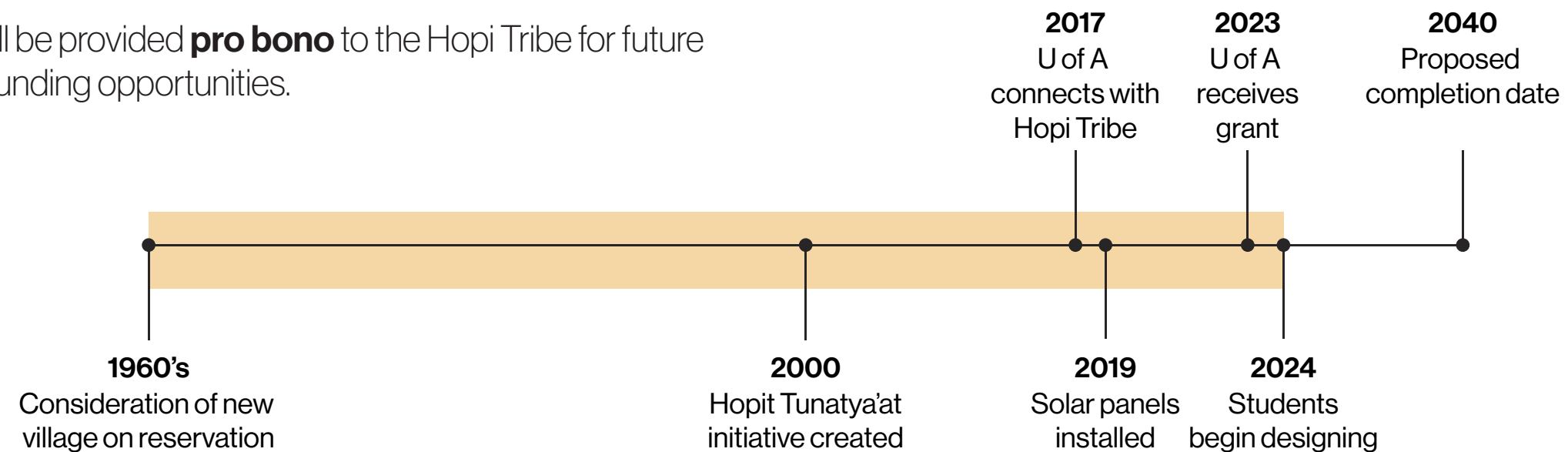
College of Architecture,
Planning & Landscape
Architecture

- Project is a **partnership** between the Hopi Tribe and the Native Peoples Design Coalition (NPDC) at the University of Arizona
- Solar Decathlon Studio was asked by NPDC to help in providing design solutions for the Hopi for a **new community** that has been decades in the making.
- Throughout the semester, we have been in close contact with the Tribe, by visiting their Tribal Council and inviting them to Tucson for feedback.
- All design work will be provided **pro bono** to the Hopi Tribe for future development and funding opportunities.

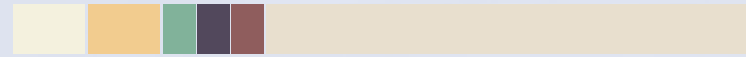


U of A SDDC '24 Design Studio at the Hopi Reservation, Jan. 2024

[CABANILLAS . MOODAY . NELSON . PEREA . WEST]



THE HOPI / culture



History.

- The Hopi have been settled in the region since 1100 AD
- Old Oraibi is the oldest continuously inhabited village in the country
- Hopi trace their ancestry to pueblo civilizations, including Mesa-Verde in Colorado.

Culture.

- **Dry Farming** - only using rainfall to irrigate their crops
- **Matrilineal Society** - Land is owned by the women in the tribe, men cannot hold land
- **Religious Traditions** - center around harvest and rainfall, which is the basis of their society
- **Clan Identities** - Hopi people identify strongly with extended families or Clans, land is distributed by clan

Values.

- Stewardship to the land
- Sustainability
- Respectful of resources
- Durability and resilience



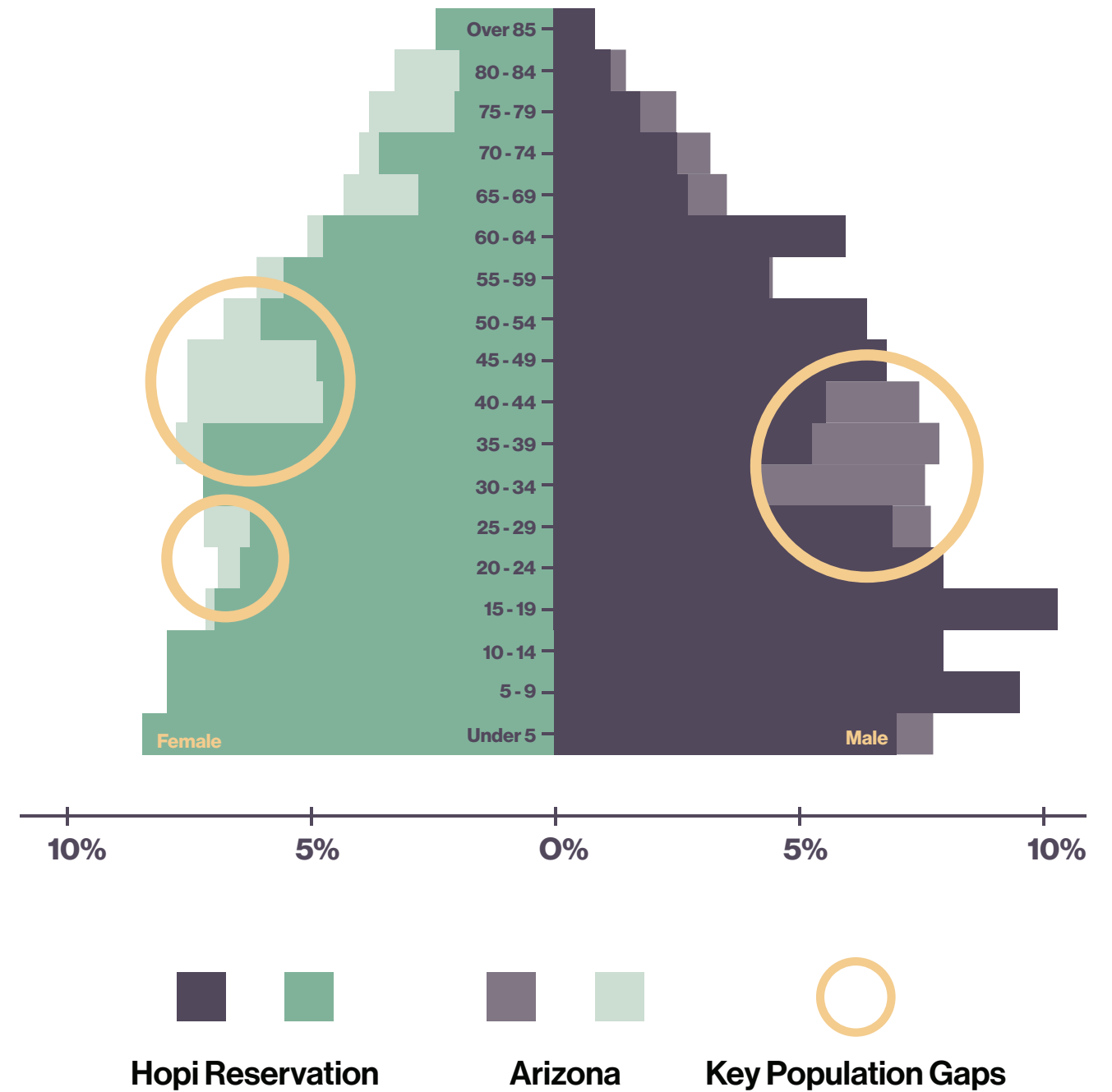
DEMOGRAPHICS / on the hopi reservation



14,000 registered tribe members

1/2 registered tribe members live on the reservation

35/100+ clans (lineages) remaining



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STATE OF HOUSING



35%

don't have access to

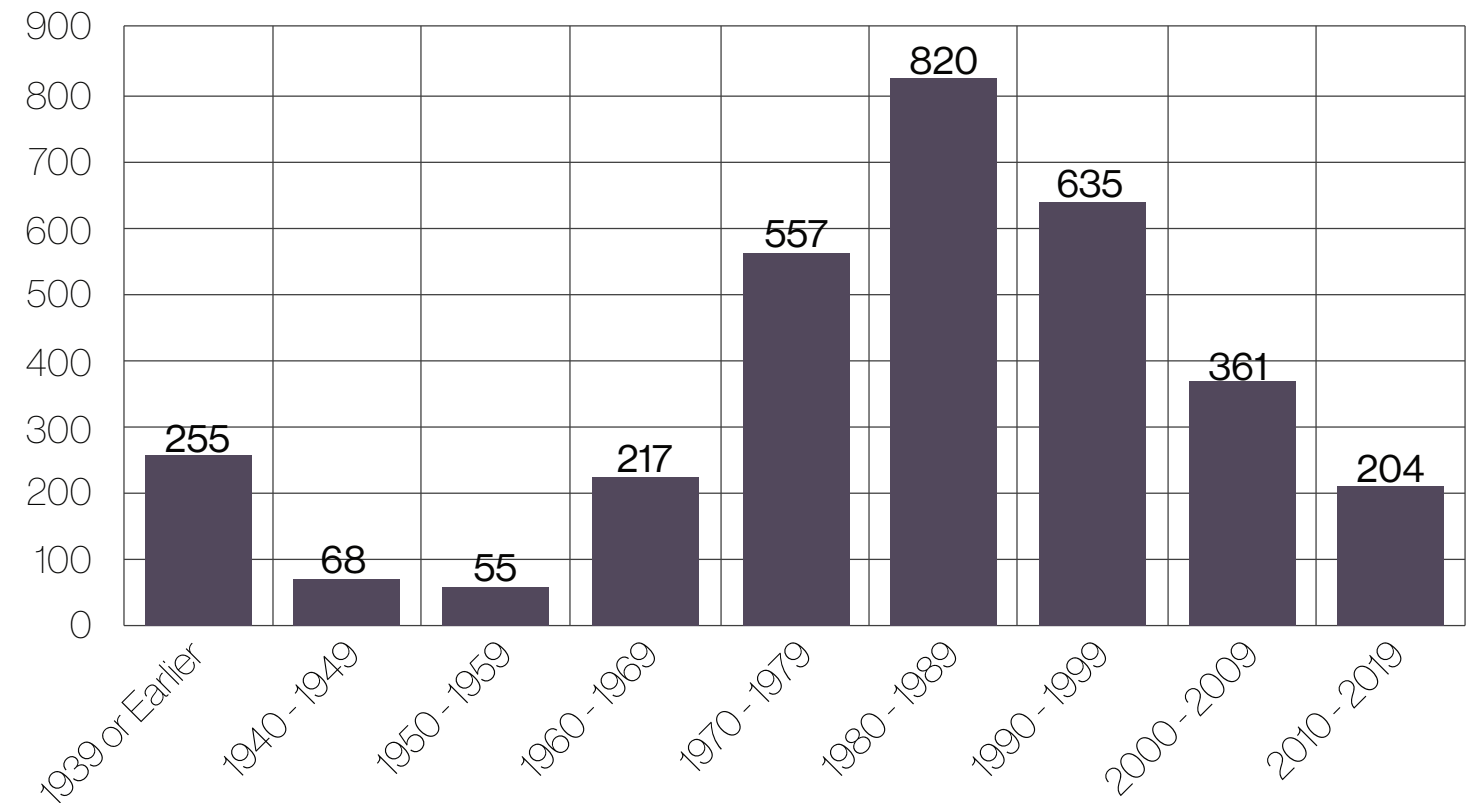
electricity + running water

making it difficult for younger families to
establish livelihoods on the reservation.

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Home Construction by Decade

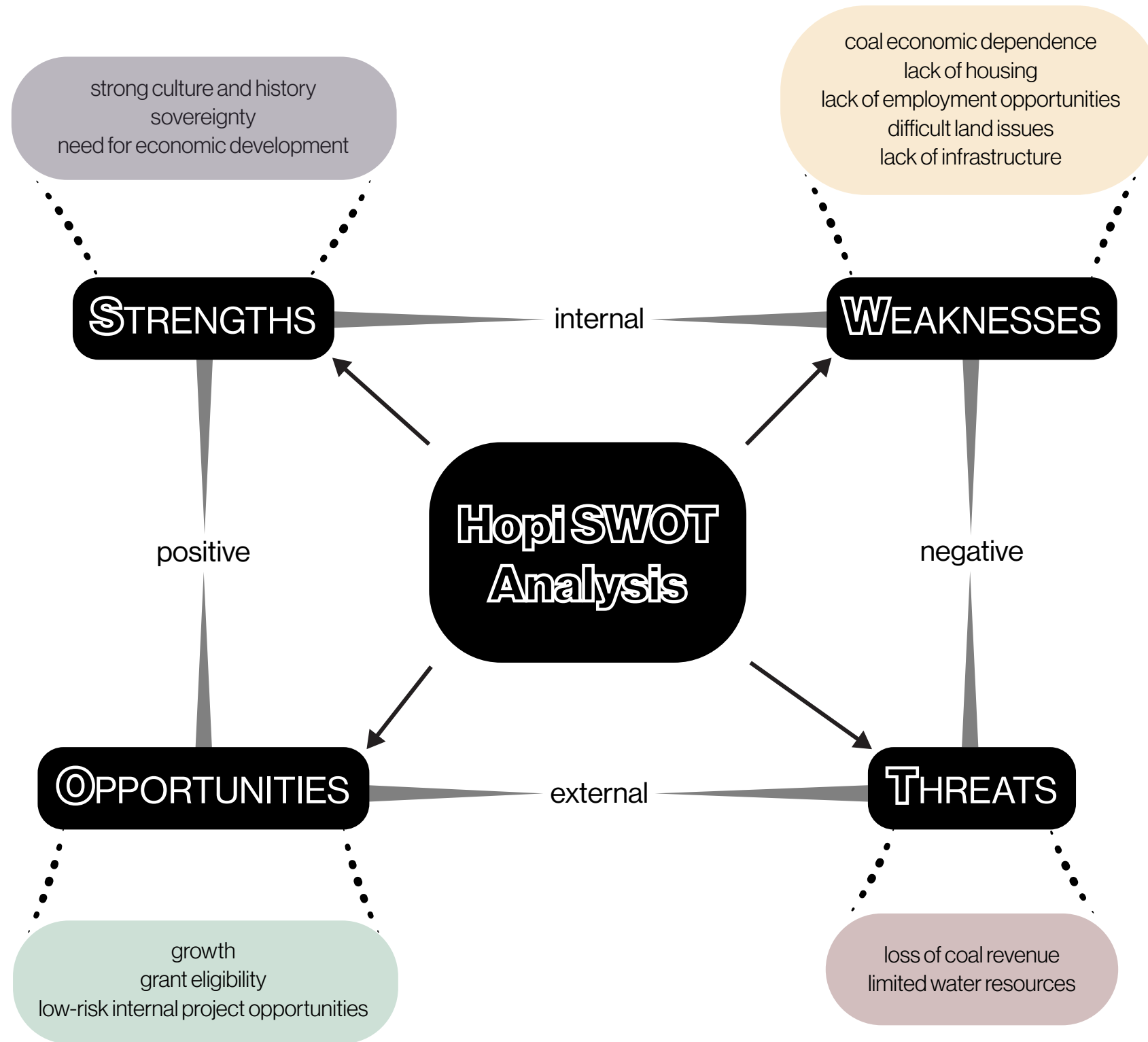


STRENGTHS. WEAKNESSES. OPPORTUNITIES. THREATS.



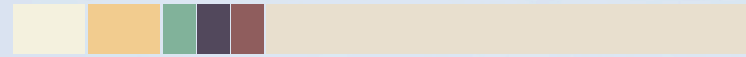
[UA ATTACHED HOUSING TEAM / solar decathlon 2024]

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SWOT Analysis
 conducted by Hopi Tribe CEDS
 Plan 2023

VISION / statement



“ Hopi should be a place where:

**Hopi culture and religion are strong;
Sacred sites are protected;
Culturally and environmentally
sensitive development occurs;
The land is looked after;
There are jobs and businesses;
Quality infrastructure serves
everyone;
Everyone has their own quality house;
Public service facilities serve all
needs.**

”

-Hopit Tunatya’at 2000

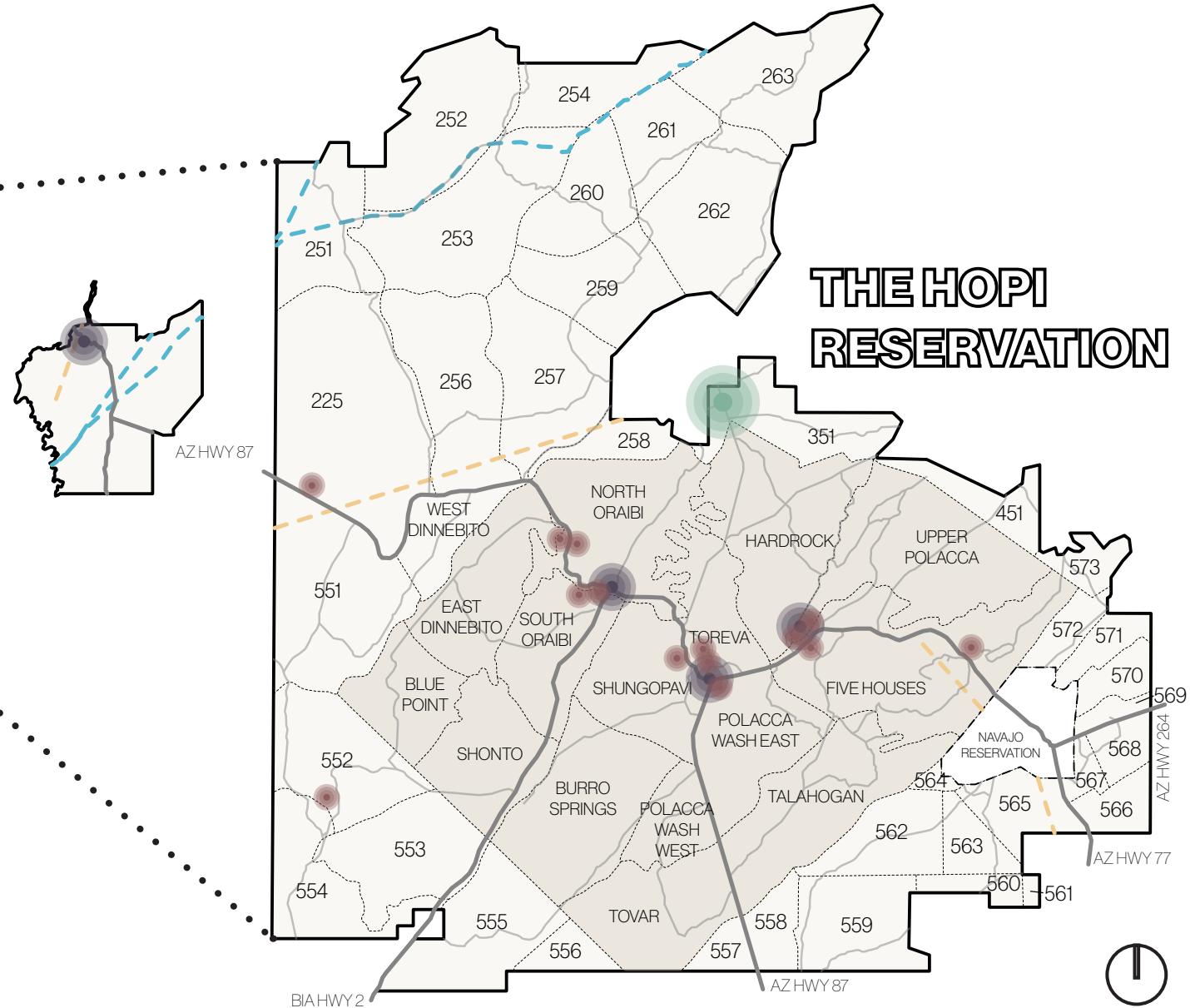
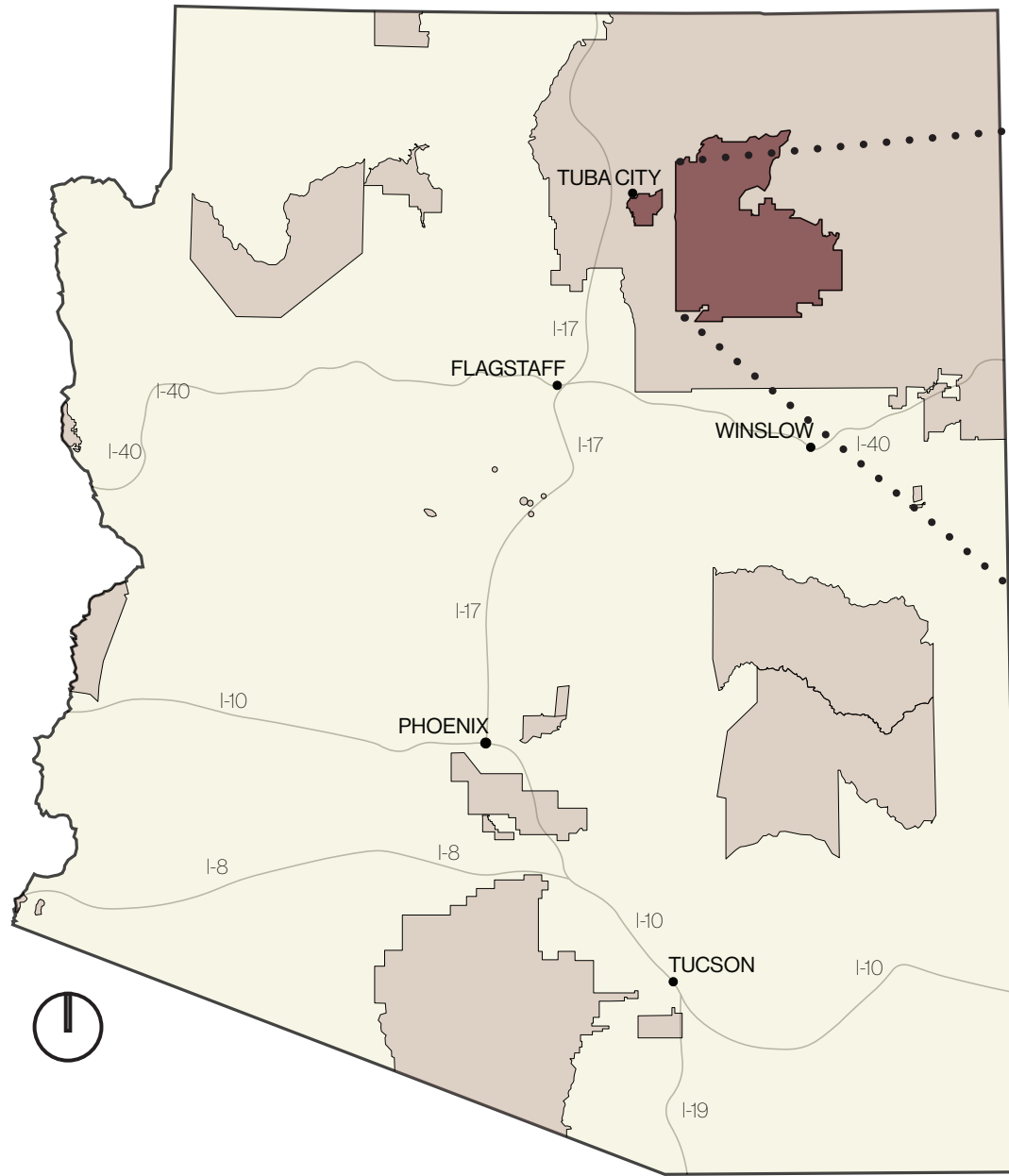
The mission of this project is to address the drastic housing need on the Hopi reservation by providing affordable, energy independent, and sustainable housing to foster a comfortable and stable lifestyle within a vibrant close-knit community while celebrating and being true to Hopi Values.









THE HOPI / location



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-  Tawa'ovi Village
-  Clan-Designated Land
-  Highways
-  Current Main Villages
-  Range Unit Boundary
-  Secondary Roads
-  Major Population Center
-  Electrical Transmission Lines
-  Current Water Pipelines

5B

ASHRAE Climate Zone

Cool, dry winters. Warm, dry summers.
Heating dominated.

TAWA'OVI / master plan for a new Hopi village



Present.

-Site is remote, and virtually undeveloped.

-Some progress started on Solar Farm since 2019.



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ARCHITECTURE

ENGINEERING

ENVELOPE

EFFICIENCY

GRID-INTERACTIVITY

LIFE-CYCLE

HEALTH

MARKET

COMMUNITY

TAWA'OVI / master plan for a new Hopi village



In progress.

- Design for attached housing development
- Design for multi-family complex
- Design for CTE School

- Education CTE
- Attached Housing
- Multi-family Housing



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TAWA'OVI / master plan for a new Hopi village



Looking forward...

- Fully master planned community with multiple housing developments scaled from current designs.
- Thriving community with modern amenities staying true to culture.

- Education CTE
- Attached Housing
- Multi-family Housing



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COMMUNITY



Timothy L. Nuvangyaoma
Chairman

Craig Andrews
Vice-Chairman

From Coal to Clean Power: Hopi Tribe’s Vision to Rewrite Its Energy Story Starts With Hopi Utilities Corporation, Economic Development Administration Funding

For Immediate Release

Kykotsmovi Village, Ariz. - December 27, 2021 (Newswire) - On December 13, 2021 the Economic Development Administration awarded funding to [Hopi Utilities Corporation](#) to support the Tribe's transition to a clean energy economy focused on workforce development and quality jobs on Reservation.

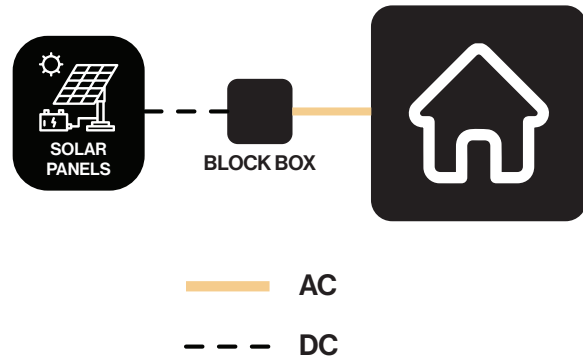
When the Navajo Generating Station (NGS) closed in 2019, it left the Hopi Tribe in incredible economic distress. The Tribe received payments for supplying coal to the NGS, representing 85% of Hopi's revenue. When these payments and jobs vanished, it left the Tribe in dire need for economic development.

Today, Hopi is rebuilding its economy with renewable energy.

GRID-INTERACTIVITY / strategy



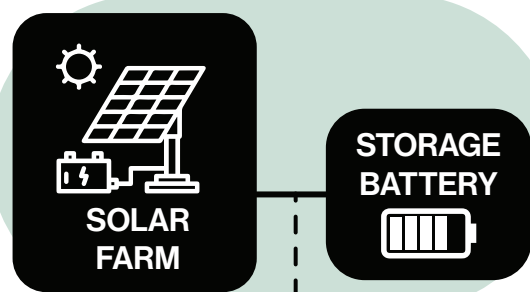
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- Each building will be a PHIUS GEB or Grid-Interactive Efficient Building.
- A solar micro-grid provides the energy to power these highly efficient buildings.
- excess solar energy **can be shared across many building clusters** or neighborhoods in a BlockLoop, with **19% more efficiency** than traditional grids.
- A central solar farm stores reserve energy for later use, when individual buildings may not be able to generate all of their own energy.

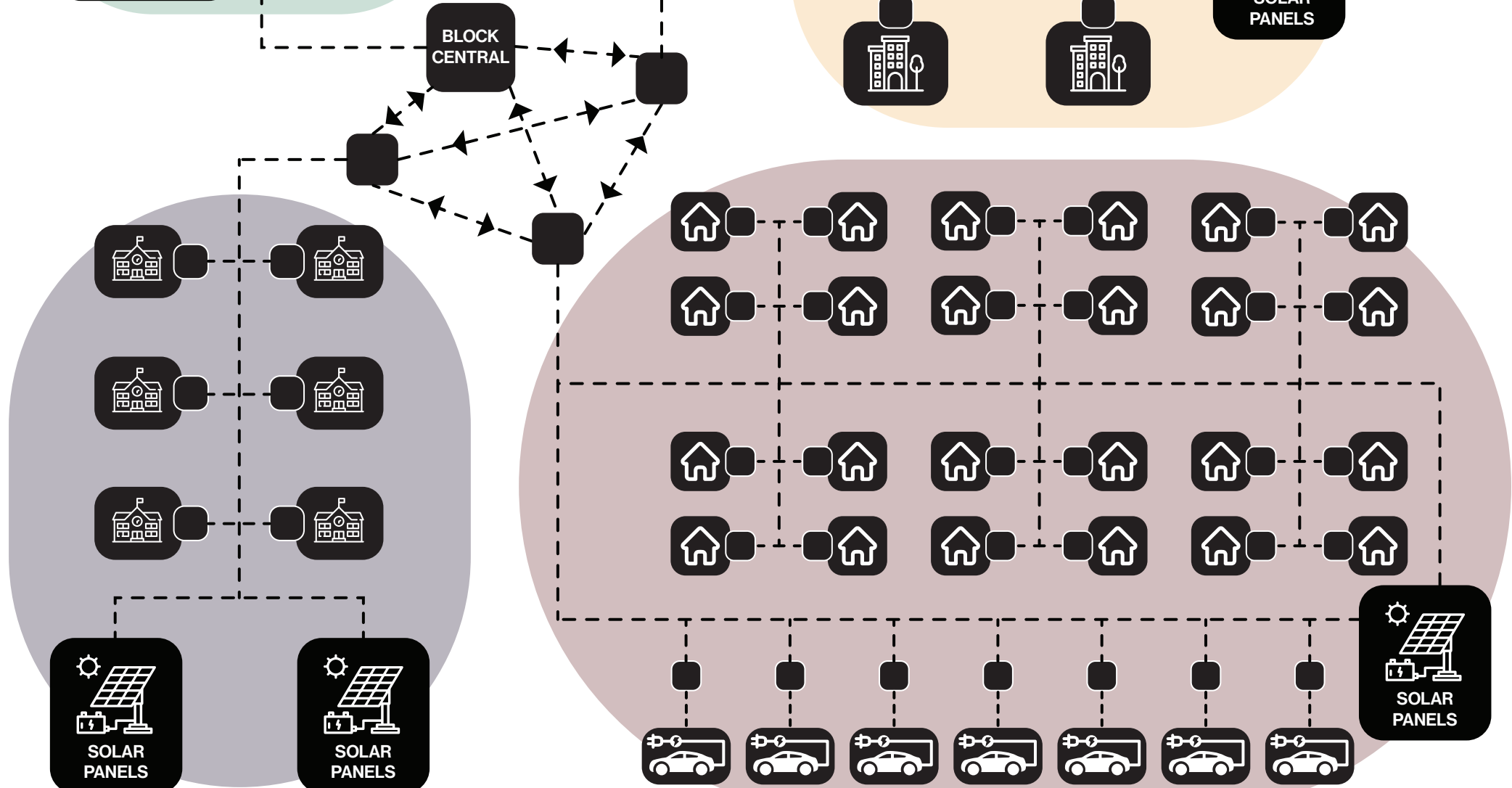
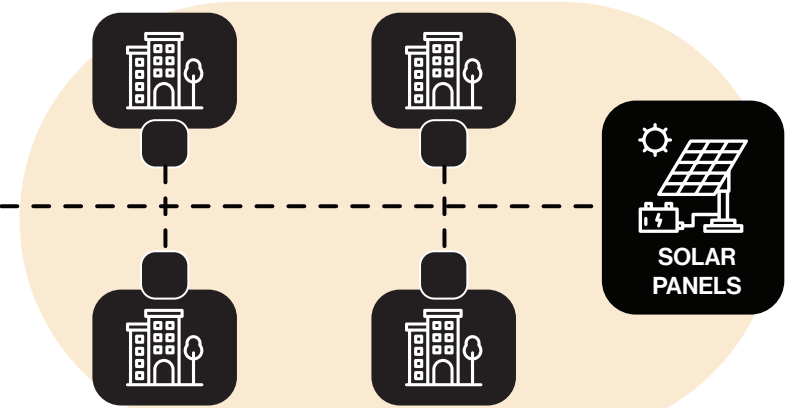


TAWA'OVI SOLAR FARM



- = BLOCKBOX™
 - block controls
 - battery
 - AC power converter
 - manages power sharing

MULTIFAMILY SOLAR GRID








EDUCATION SOLAR GRID

ATTACHED HOUSING SOLAR GRID

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TAWA'OVI /master plan



-  Tawa'Ovi Solar Farm
-  Wastewater Treatment
-  Water Main
-  PV lines to solar farm
-  Water Treatment Line

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ENGINEERING

ENVELOPE

EFFICIENCY

GRID-INTERACTIVITY

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HEALTH

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COMMUNITY

DESIGN GOALS



[UA ATTACHED HOUSING TEAM / solar decathlon 2024]

[CABANILLAS . MOODAY . NELSON . PEREA . WEST]

**Requests of
the Hopi**

Celebrate Culture

- familiar housing typologies
- reinterpreting traditional motifs

Responses

- tiered form
- accessible roofs for drying crops
- use of traditional materials and techniques

ARCHITECTURE

ENGINEERING

ENVELOPE

EFFICIENCY

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LIFE-CYCLE

HEALTH

MARKET

COMMUNITY

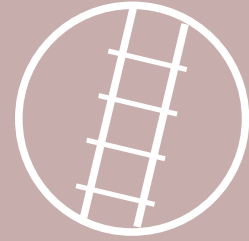
DESIGN GOALS



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- provide spaces for community gatherings
- connection to local resources and community

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- community outdoor spaces
- paths connecting to education and services

DESIGN GOALS



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Prioritize Efficiency

- optimized for resources
- designed for the climate
- responsible to the land
- easy to construct

- designed to meet Phius ZERO standards
- prefabricated construction
- incorporation of passive design strategies
- high efficiency, low cost mechanical systems

DESIGN GOALS

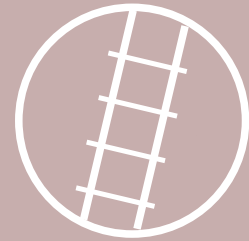


[UA ATTACHED HOUSING TEAM / solar decathlon 2024]

[CABANILLAS . MOODAY . NELSON . PEREA . WEST]

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Promote Well-being

- implementing an architecture that fulfills a comfortable and healthy standard of life amid a harsh desert environment

- use of berms and entry wall to block dust
- incorporation of native vegetation in landscape
- ERV to maintain indoor air quality

ARCHITECTURE

ENGINEERING

ENVELOPE

EFFICIENCY

GRID-INTERACTIVITY

LIFE-CYCLE

HEALTH

MARKET

COMMUNITY



Passive House Institute U.S.

Thermal Control.

Thermal control helps keep the inside warmer when it's cold outside, and cooler when it's hot outside — to maximize comfort and energy efficiency.

Air Control.

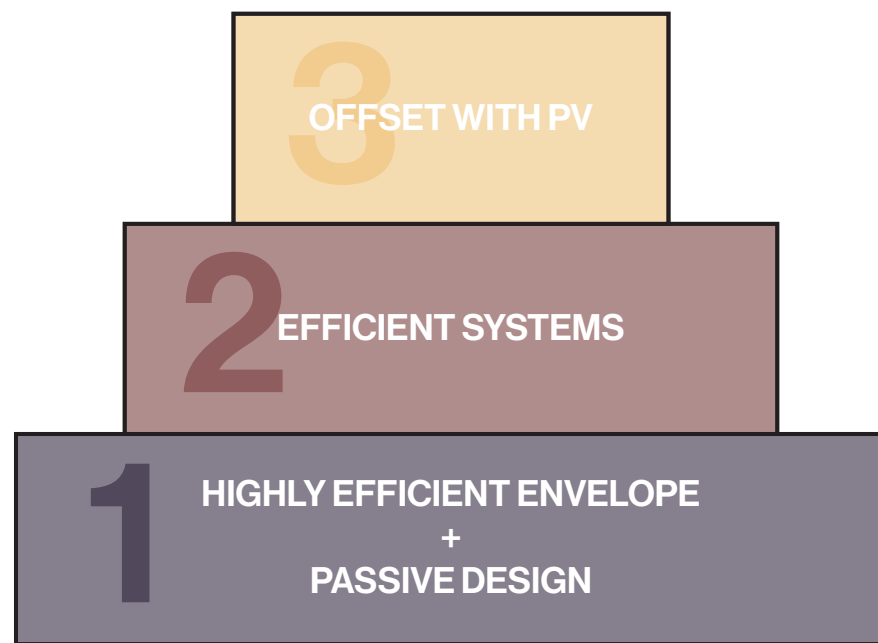
Passive buildings achieve air control by air sealing the enclosure and then providing balanced, mechanical ventilation to achieve superior indoor air quality.

Radiation Control.

Phius-optimized buildings balance solar radiation — taking advantage of it when needed and shading when not to lighten the cooling load and maximize energy efficiency.

Moisture Control.

Passive buildings require special attention to moisture control both in proper vapor and moisture control design for the enclosure as well as the mechanical systems needed to maintain appropriate moisture levels in the space.



Steps to Net-Zero

SITE / strategy

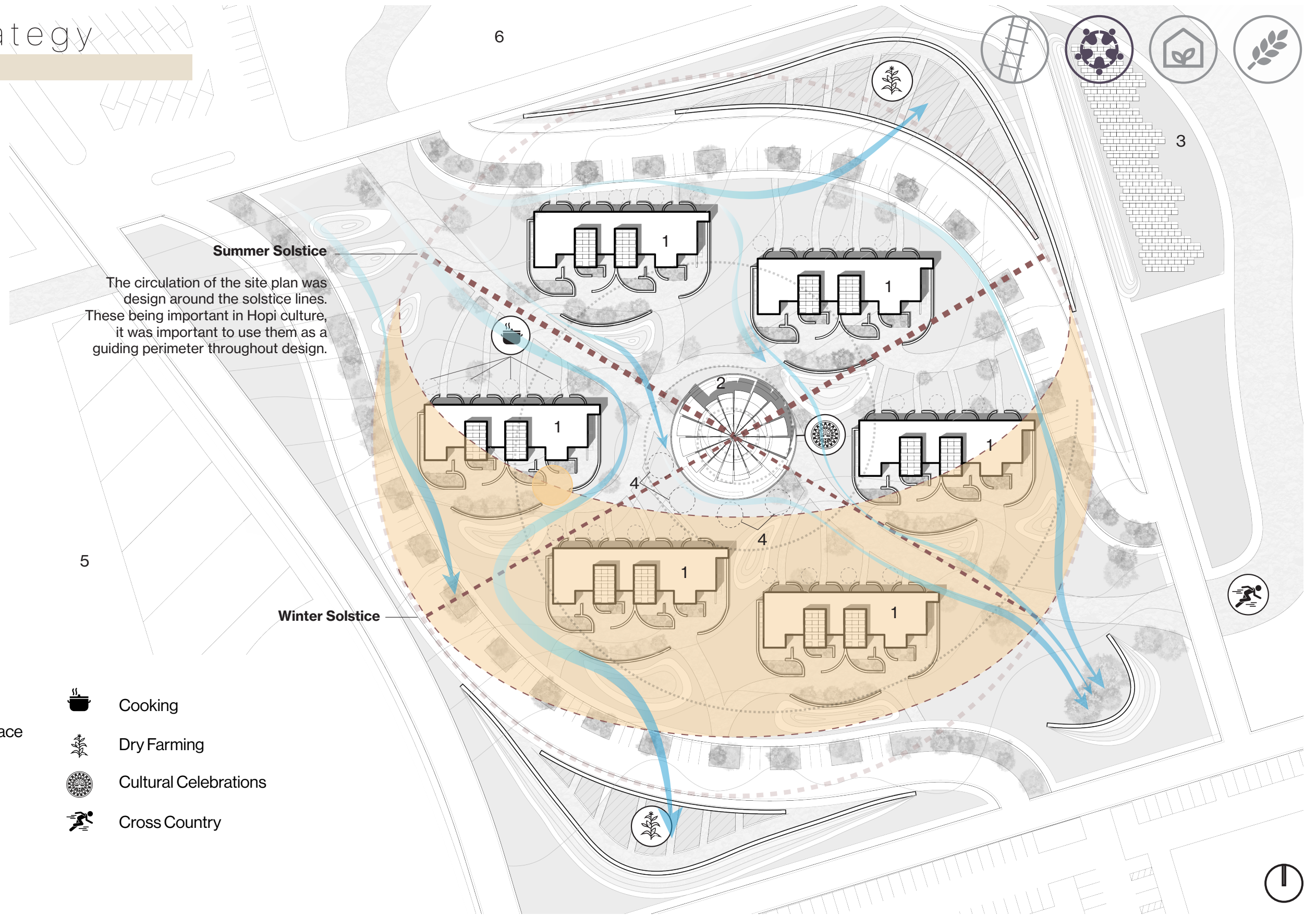


Site Intentions.

- Orient housing clusters on North-South Axis for optimal solar control.
- Create communal greenbelts to encourage socialization, physical activity, and gardening.
- Create berms to deflect wind and create outdoor privacy.

Summer Solstice
The circulation of the site plan was design around the solstice lines. These being important in Hopi culture, it was important to use them as a guiding perimeter throughout design.

Winter Solstice



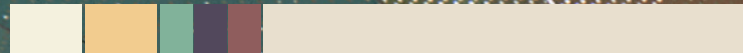
Site Plan Key:

- 1. Unit Clusters
- 2. Communal Gathering Space
- 3. Solar Farm
- 4. Roasting Pits
- 5. Education Site
- 6. Multi-Family Site

- Cooking
- Dry Farming
- Cultural Celebrations
- Cross Country



COMMUNITY PLAZA / rendering



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[CABANILLAS . MOODAY . NELSON . PEREA . WISZ]

Roasting Pits

Outdoor Kitchen

Central Gathering Plaza
For community celebrations

ARCHITECTURE

ENGINEERING

ENVELOPE

EFFICIENCY

GRID-INTERACTIVITY

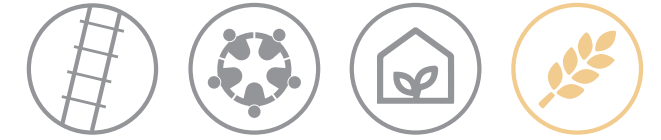
LIFE-CYCLE

HEALTH

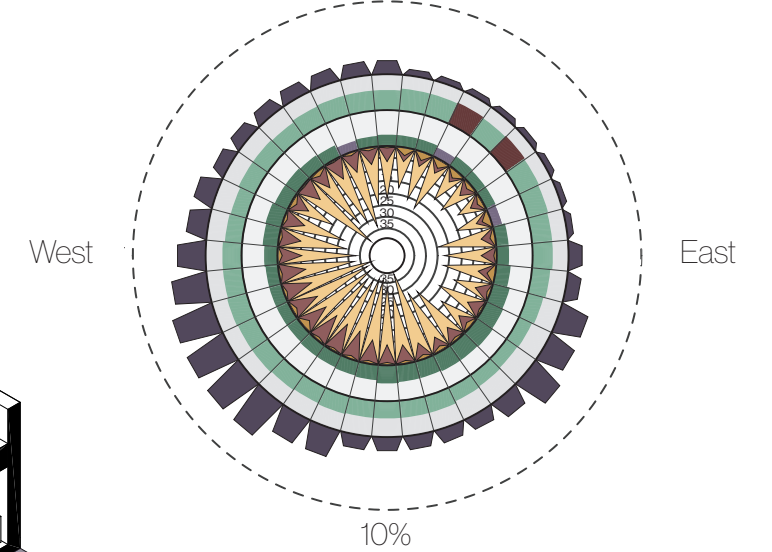
MARKET

COMMUNITY

LIFESTYLE / health + well-being



Wind Rose



Site

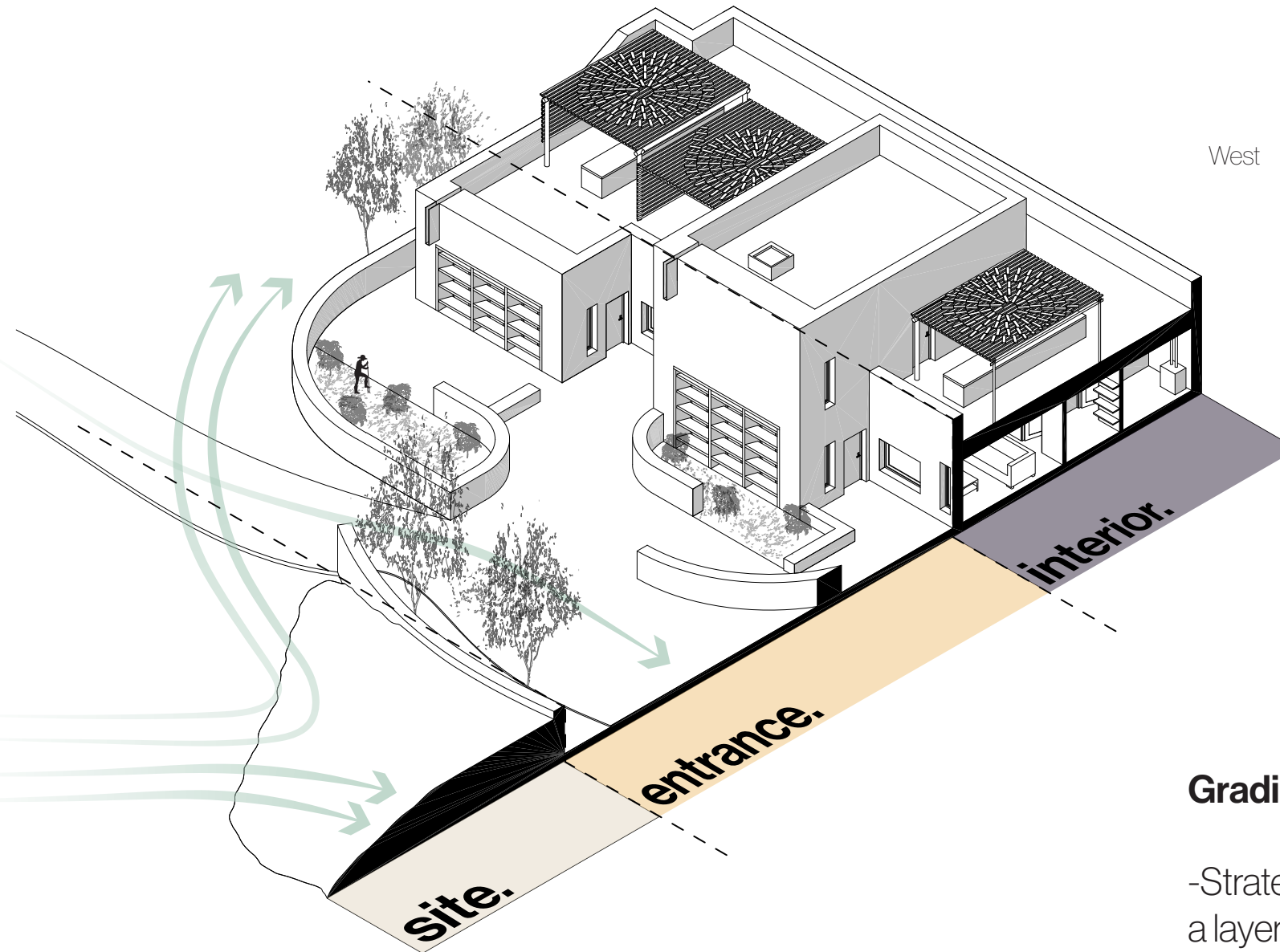
The location of the berms and walls creates a physical obstruction that prevents wind from blowing dust particles into the interior of the units.

Entrance

The vegetation outside of the units promotes health by absorbing pollutants and contributing to a calming environment that supports mental well-being.

Interior

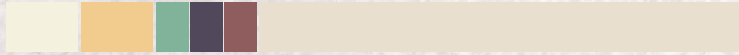
While the ERV exchanges stale indoor air with fresh outdoor air, ensuring efficient ventilation, the use of low VOC materials and finishes removes the potential of formaldehyde in the air, both of which contribute to healthy indoor air quality.



Gradient of Strategies.

-Strategies are implemented in a layered approach from the site to interior to maintain healthy environments for our occupants.

ARCHITECTURE / rendering



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Drainage Canales - deliver water to gardens and provide visual connection to water

Tiered Massing - familiar architectural typology, giving a sense of home to the community

Accessible Roof Top
For communal living

Sandstone Walls
Incorporates traditional and local building materials.

ARCHITECTURE

ENGINEERING

ENVELOPE

EFFICIENCY

GRID-INTERACTIVITY

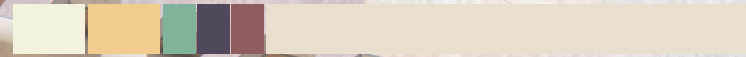
LIFE-CYCLE

HEALTH

MARKET

COMMUNITY

ACCESSIBLE ROOFTOP / rendering



Outdoor Gathering

Provide outdoor gathering spaces for individual residents that can be opened up to other residents for impromptu gatherings.

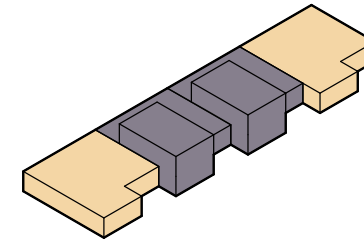
Ramada
Place for drying Hopi corn.

CONDOMINIUMS / floor plans



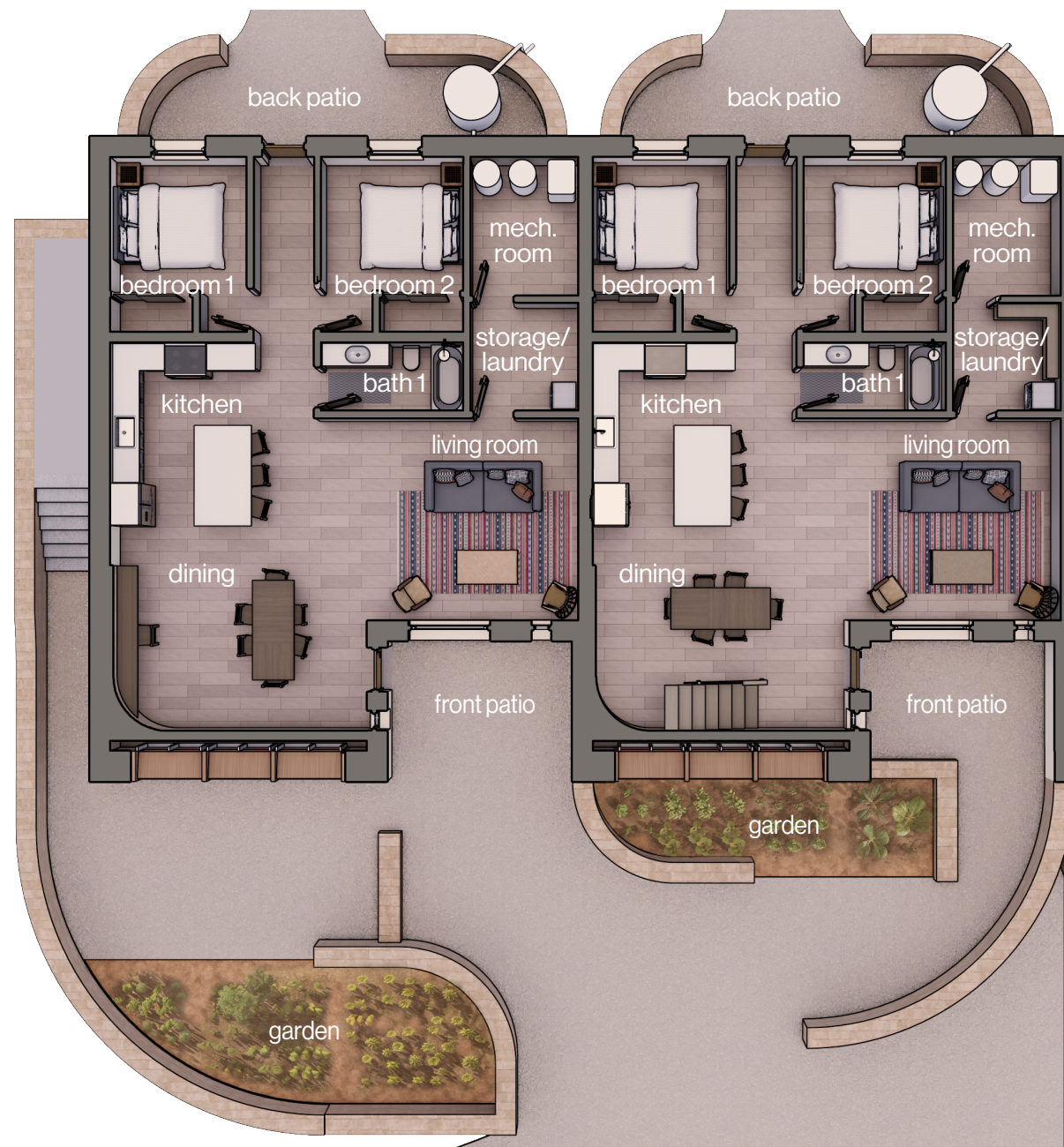
Cluster Aggregation

- 2x 3 Bed/ 2 Bath
- 2x 2 Bed/ 1 Bath
- 4x Units Per Cluster

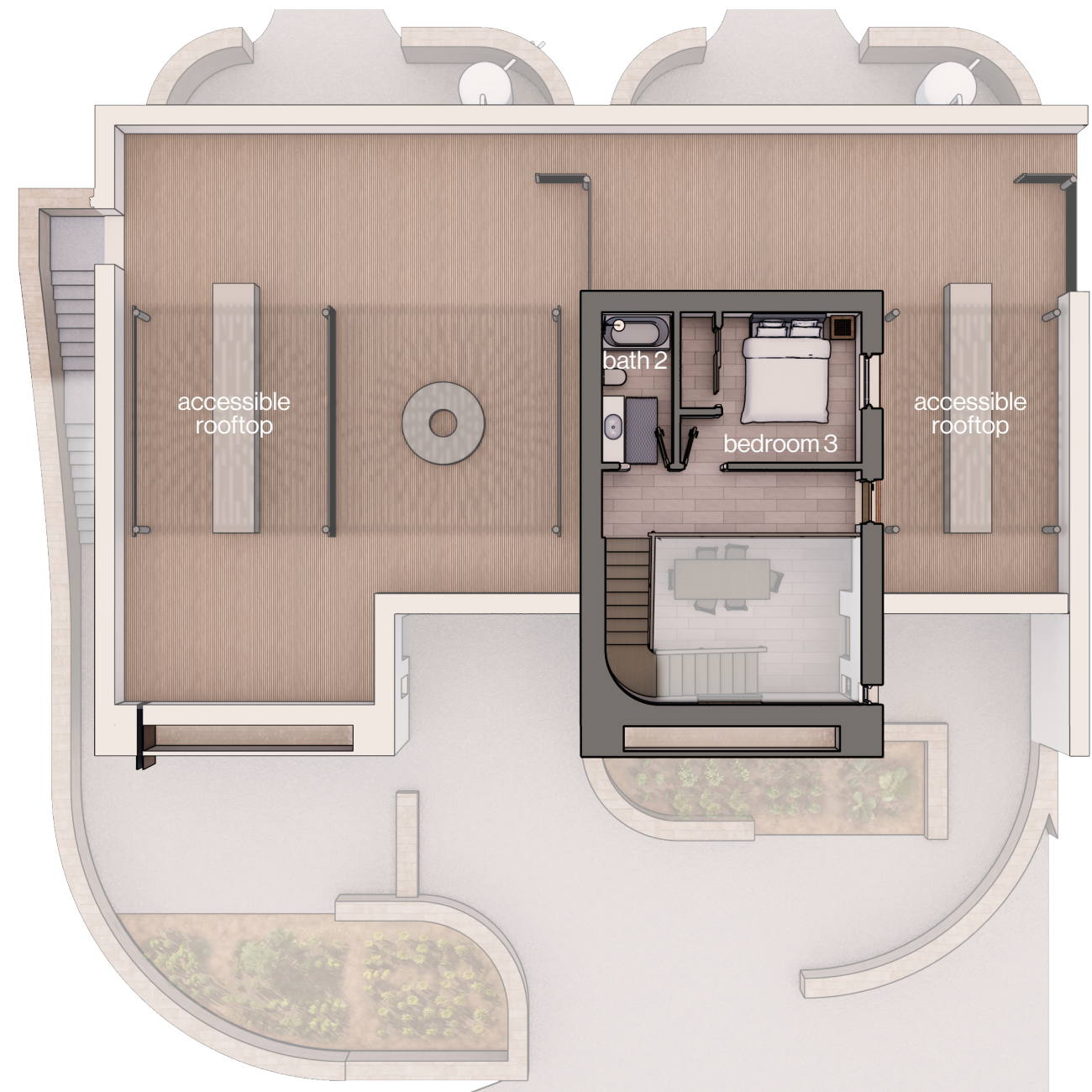


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Level 01 - Floor Plan



Level 02 - Floor Plan (3 bed unit only)



ARCHITECTURE

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ENVELOPE

EFFICIENCY

GRID-INTERACTIVITY

LIFE-CYCLE

HEALTH

MARKET

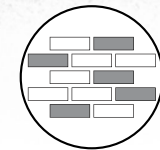
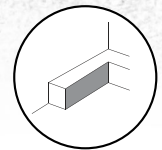
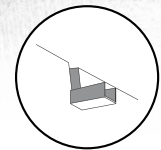
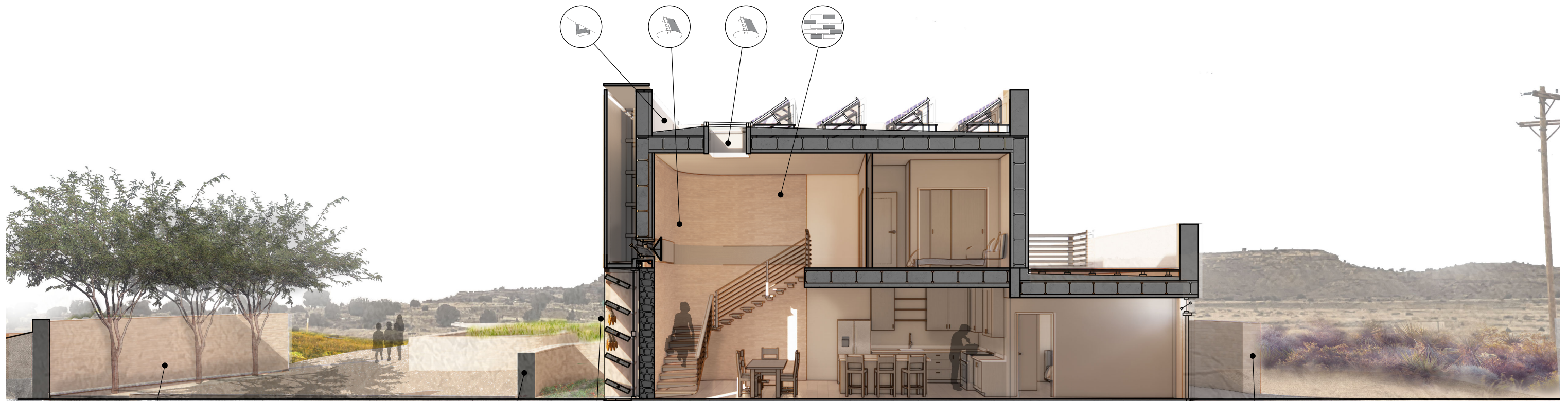
COMMUNITY

ARCHITECTURAL / section



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canales

traditional benches

drying crops

reference to kiva

sandstone

ARCHITECTURE

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ENVELOPE

EFFICIENCY

GRID-INTERACTIVITY

LIFE-CYCLE

HEALTH

MARKET

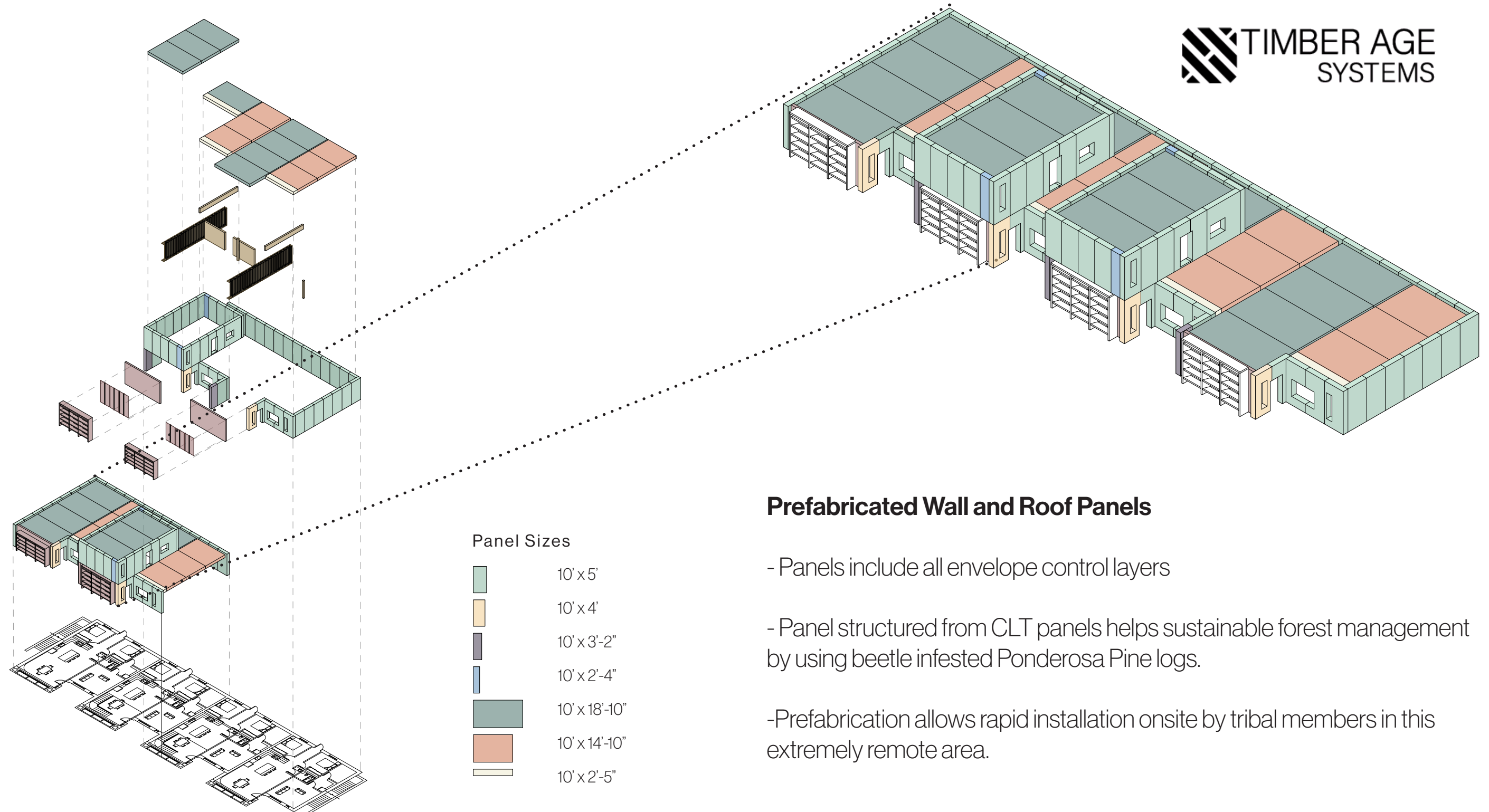
COMMUNITY

SUSTAINABLE STRUCTURE / prefab mass timber panels



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[CABANILLAS . MOODAY . NELSON . PEREA . WEST]



Prefabricated Wall and Roof Panels

- Panels include all envelope control layers
- Panel structured from CLT panels helps sustainable forest management by using beetle infested Ponderosa Pine logs.
- Prefabrication allows rapid installation onsite by tribal members in this extremely remote area.

ARCHITECTURE

ENGINEERING

ENVELOPE

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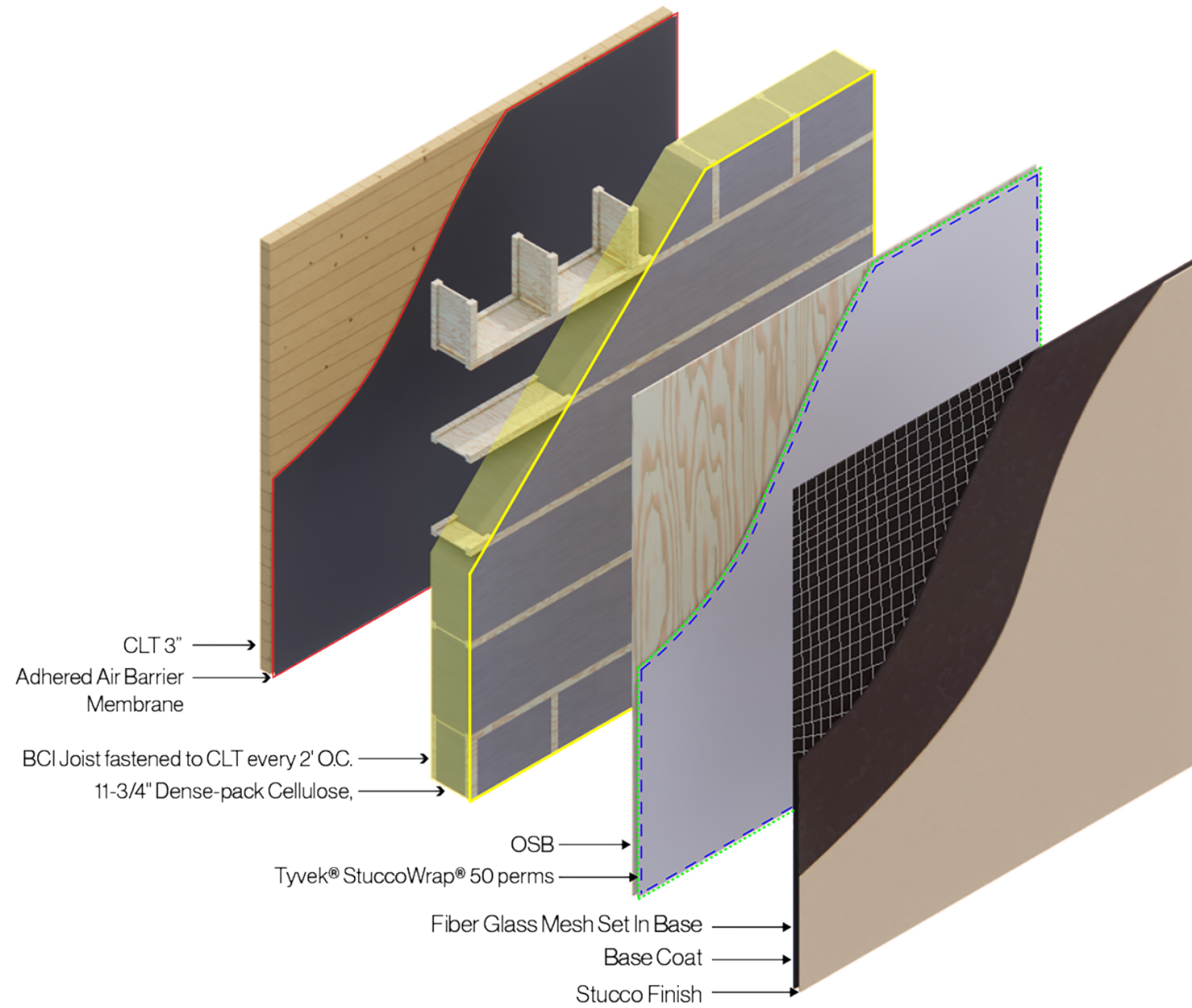
COMMUNITY

PREFAB STRUCTURAL PANEL / assembly



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[CABANILLAS . MOODAY . NELSON . PEREA . WEST]



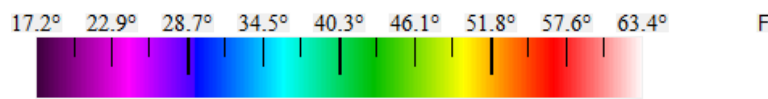
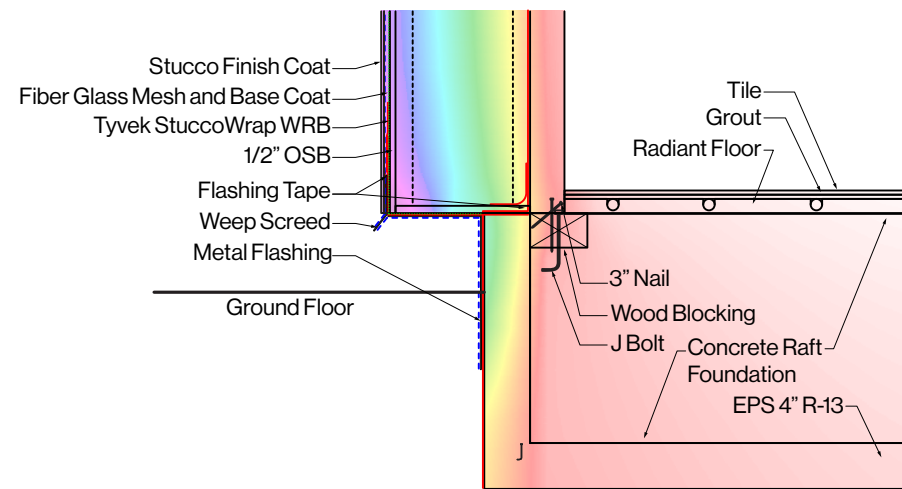
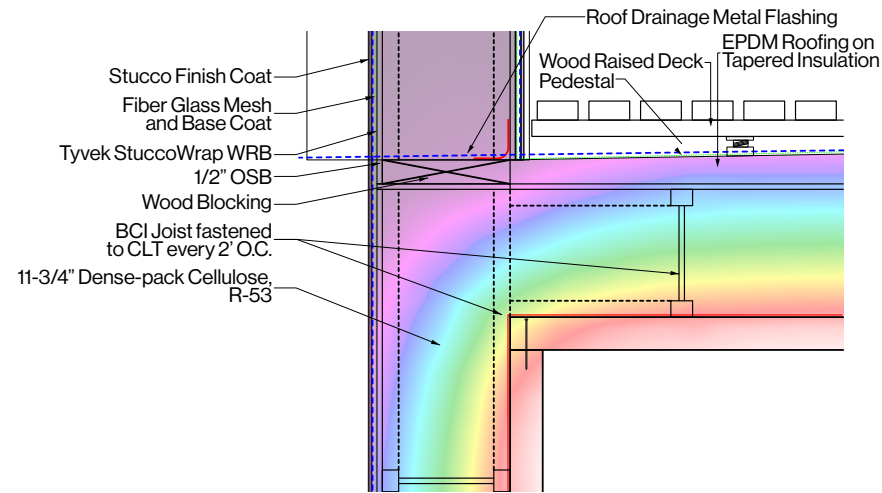
- Drainage Plane
- - - - -
- Vapor Control Layer
.....
- Thermal Envelope
—————
- Air Barrier
—————

- CLT 3", R-3.75
+
11-3/4" Dense-pack Cellulose, R-47
+
Synthetic Stucco Coats, R-4
Total Wall Assembly = R-54.75

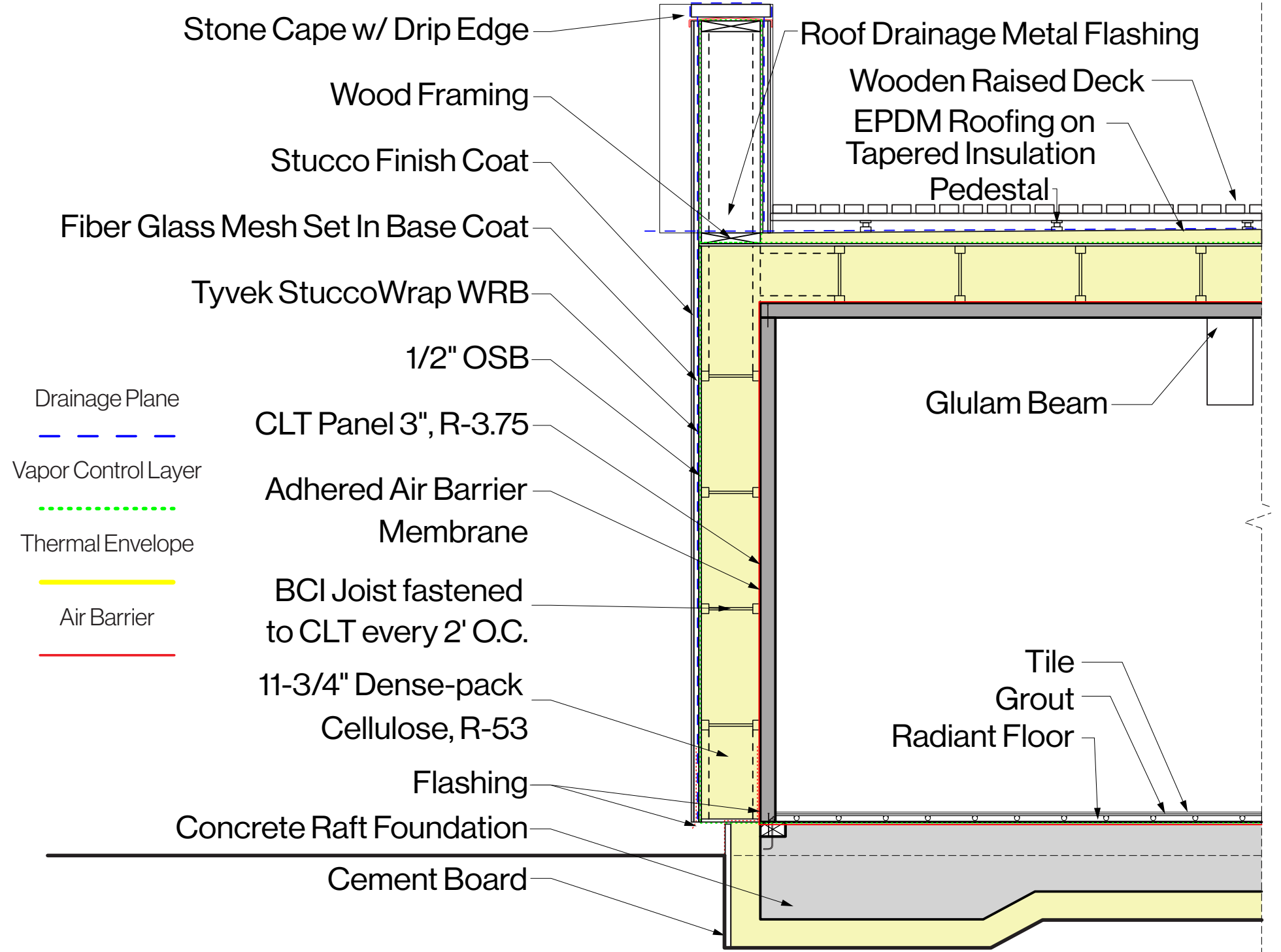
ENVELOPE / wall section



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[CABANILLAS . MOODAY . NELSON . PEREA . WEST]

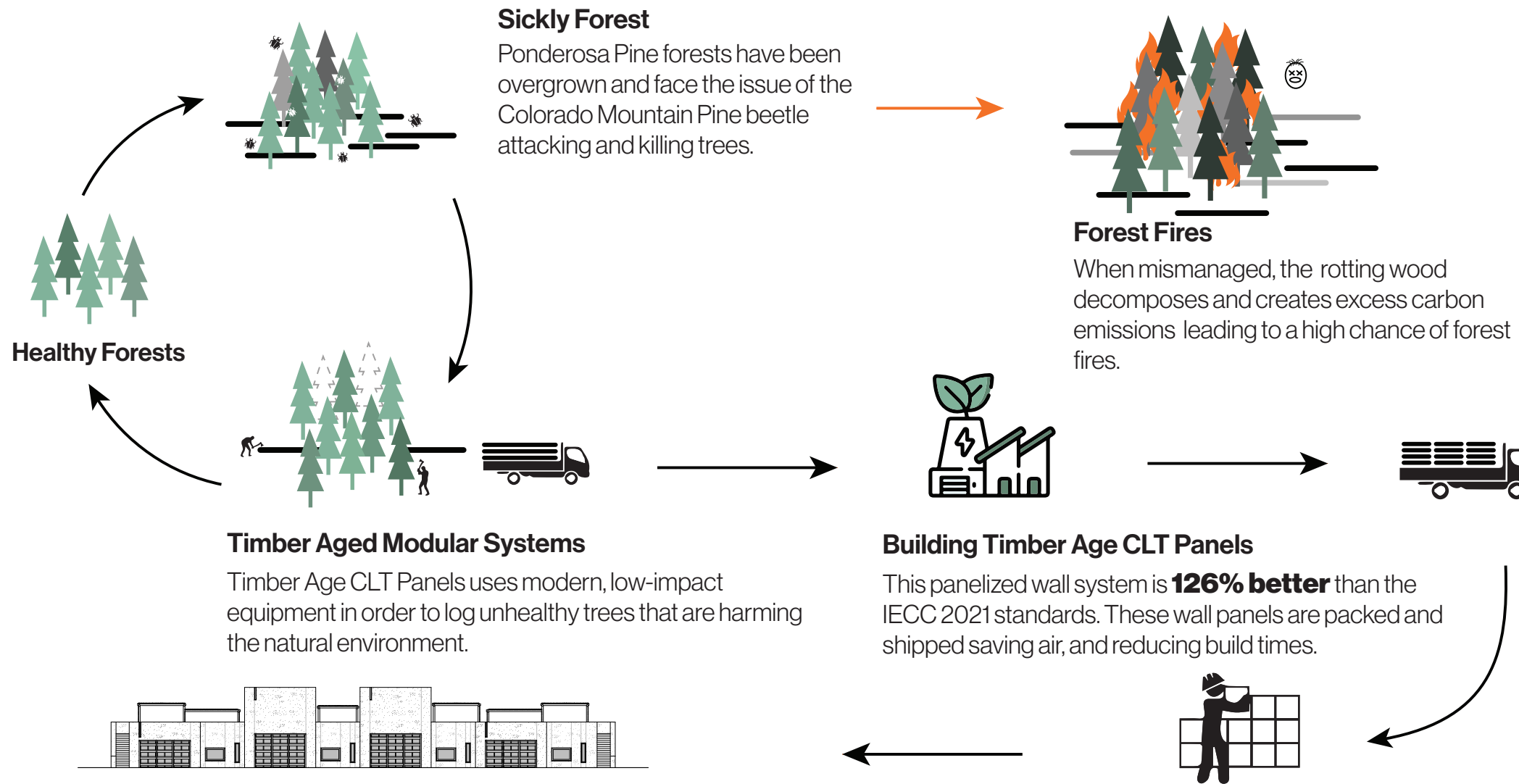


BUILDING LIFE CYCLE / carbon impact

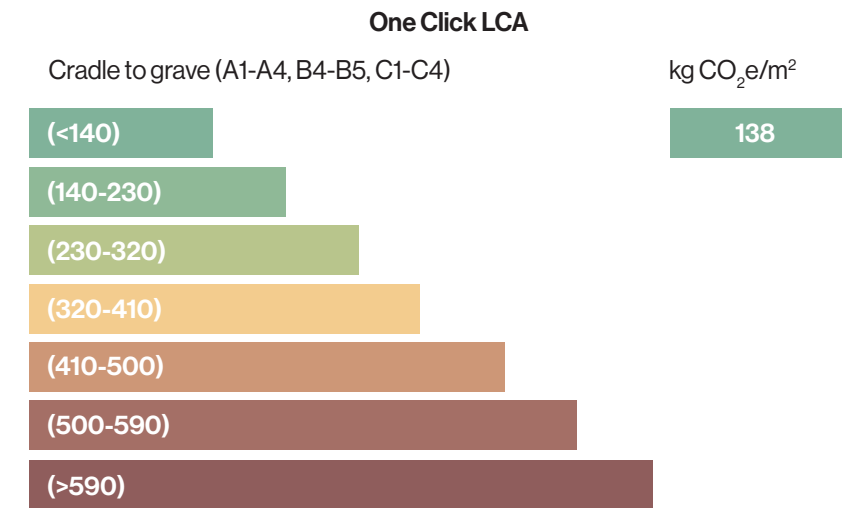


[UA ATTACHED HOUSING TEAM / solar decathlon 2024]

[CABANILLAS . MOODAY . NELSON . PEREA . WEST]



138 /kgCO₂e/m² carbon emissions from cradle to grave



How Much Carbon is Really Being Used?

Over the lifetime of the building, it is estimated that **138 kg CO₂ e/m²** over its lifetime. The high efficiency panels are **Passive House Certified**.

WINDOW / details



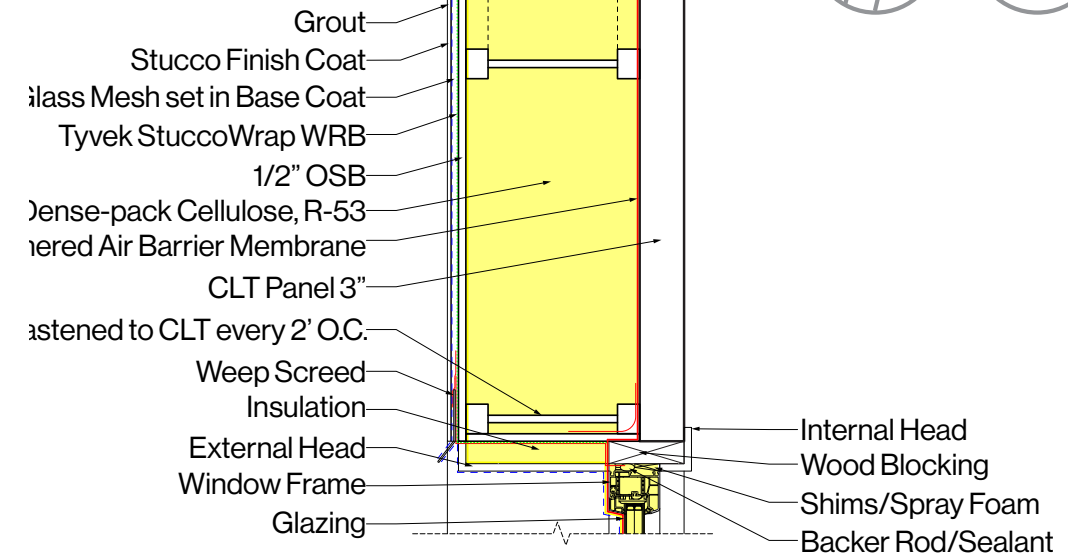
Alpen Tyrol TR-6 Series
 plus certified. triple paned. low-e.



0.106 /window-to wall ratio

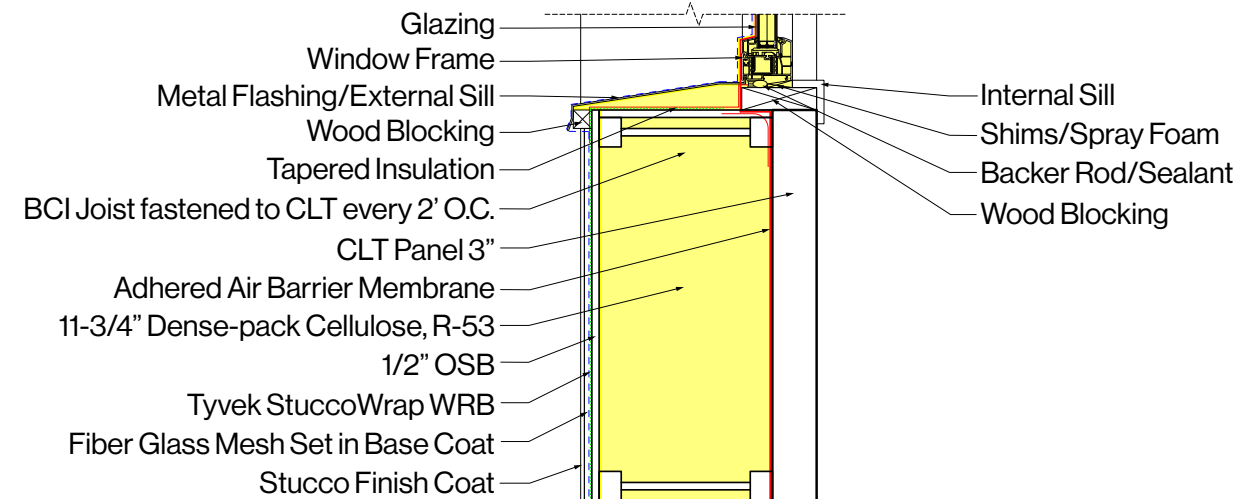
0.35 /SGHC

0.16 /whole window U-value



window head detail

1" = 1' - 0"



window sill detail

1" = 1' - 0"

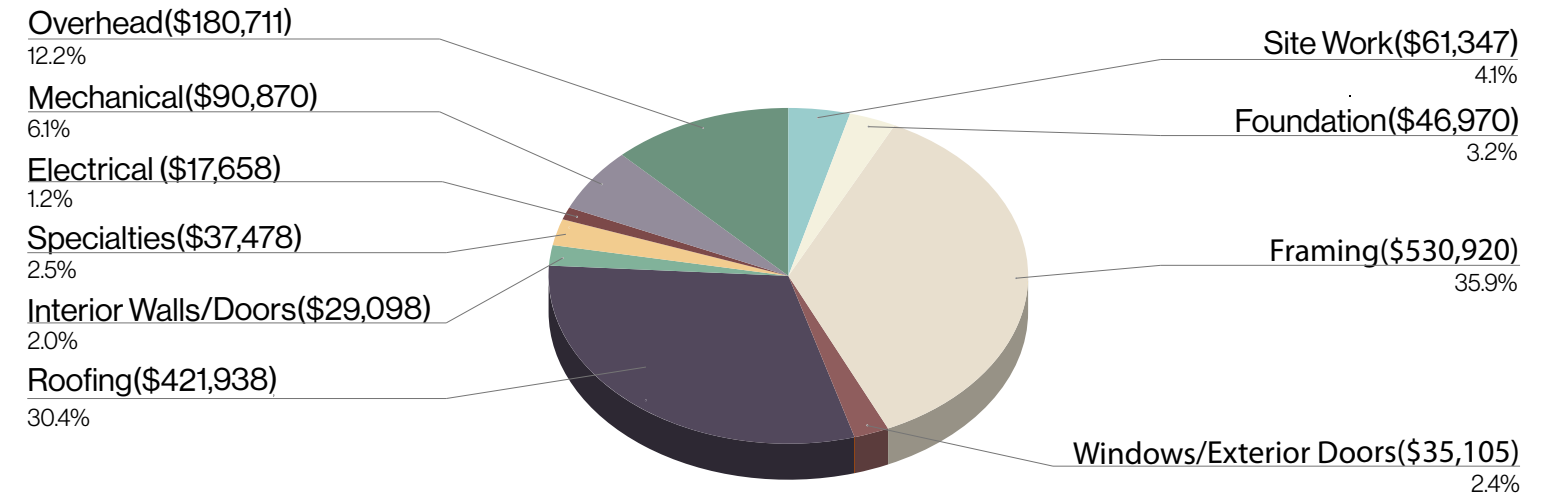
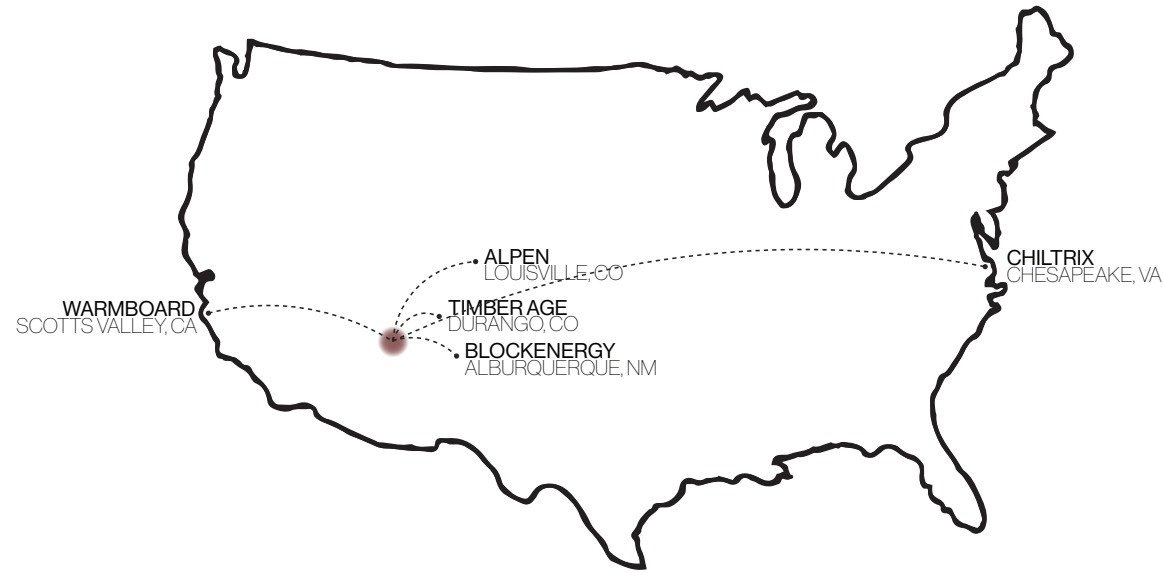
[UJA ATTACHED HOUSING TEAM / solar decathlon 2024]

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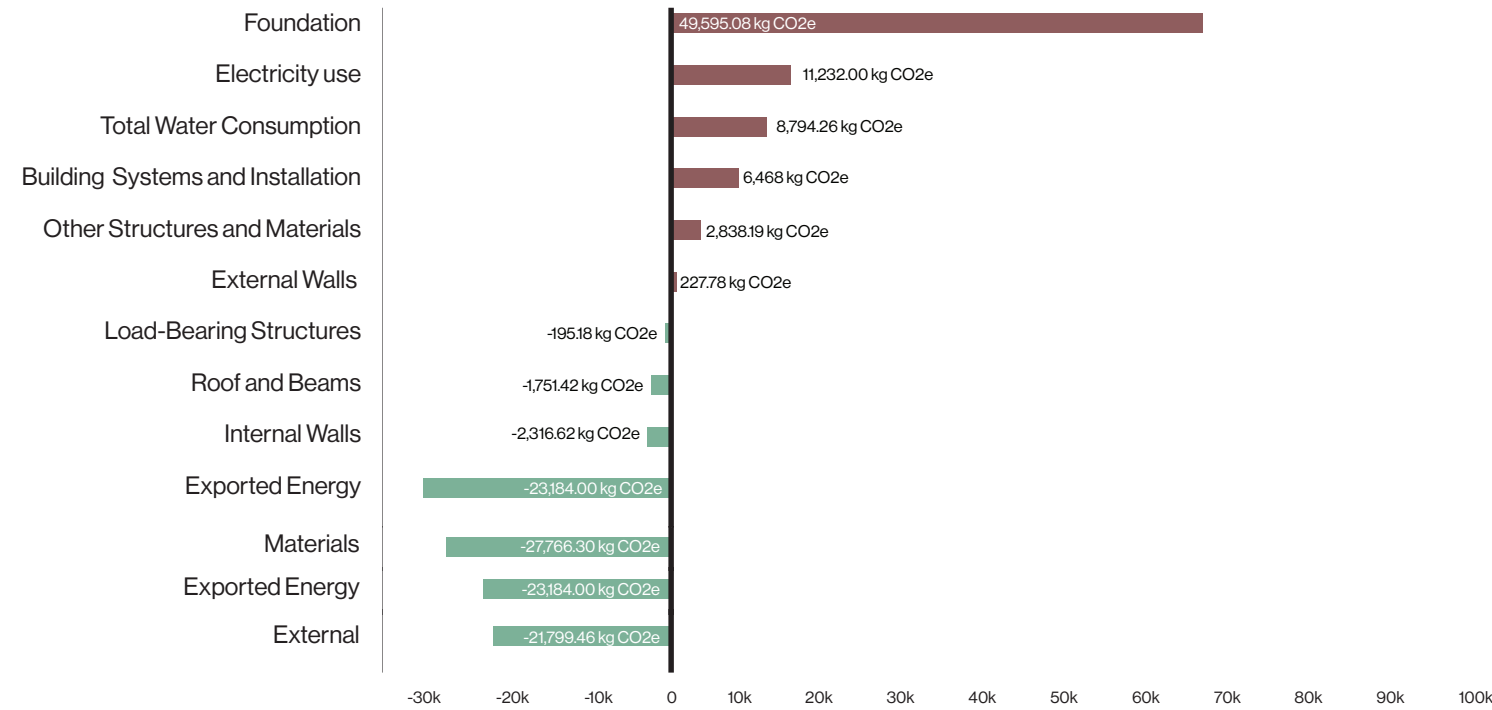
MARKET SUSTAINABILITY / materials + cost



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\$2 million / kickstart budget

With funding provided by the CARES Act of 2020

\$1.48 million / project cost

+ \$500,000

under budget

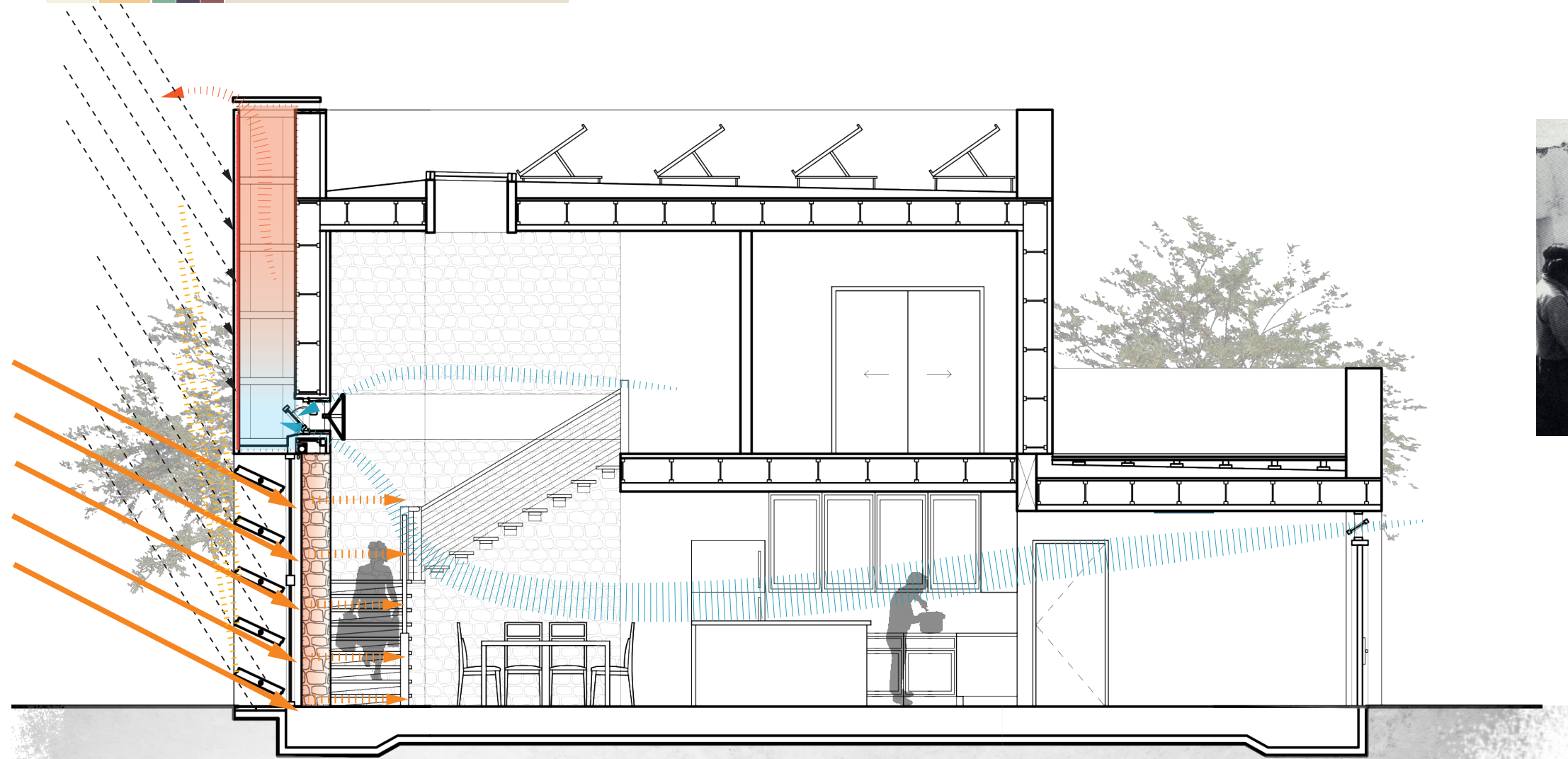
Plus studies have shown a **3.3% decrease in construction costs** compared to conventional methods after 4 years.

PASSIVE STRATEGIES / section



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- summer solar radiation
- spring/autumn solar radiation
- winter solar radiation
- time lag heat radiation from thermal mass
- fresh, cool airflow
- hot, exhausted air
- heated zinc surface, heating air in chimney



Hopi men assembling a sandstone wall.



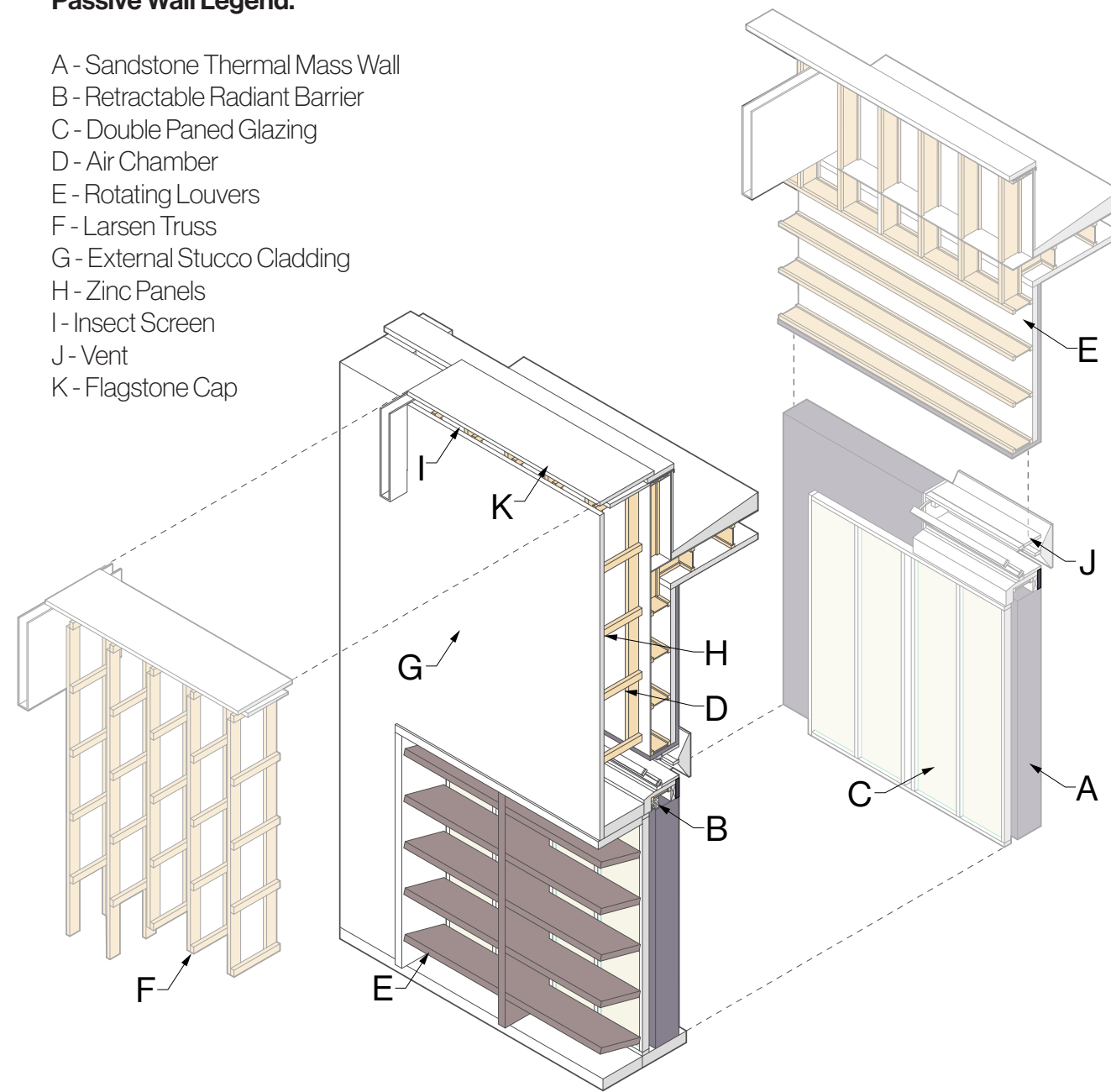
Hopi woman applying plaster to sandstone wall.

PASSIVE WALL / assembly + interior quality



Passive Wall Legend.

- A - Sandstone Thermal Mass Wall
- B - Retractable Radiant Barrier
- C - Double Paned Glazing
- D - Air Chamber
- E - Rotating Louvers
- F - Larsen Truss
- G - External Stucco Cladding
- H - Zinc Panels
- I - Insect Screen
- J - Vent
- K - Flagstone Cap



Hopi sandstone on the trombe wall seamlessly blends into the interior, creating a **space that resonates** with the occupants. It contributes both to the **aesthetic** and **thermal comfort** of the interior.

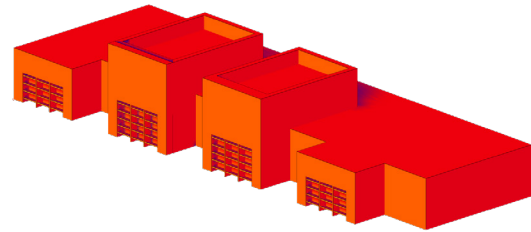
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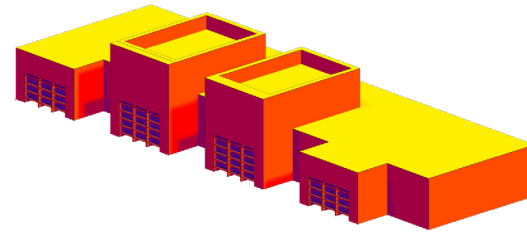
PASSIVE WALL / operation



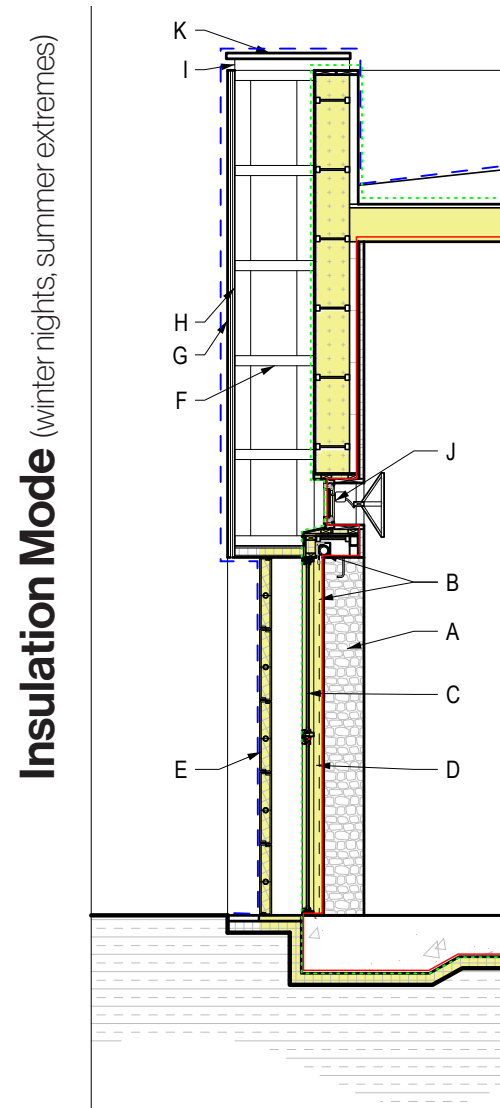
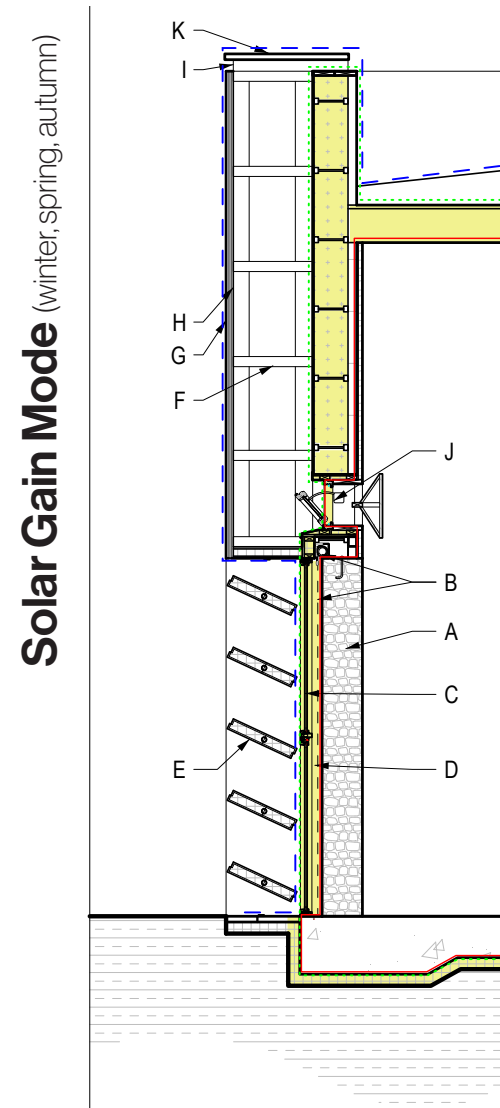
Radiation Analysis (shading effectiveness)



December (fully lit)



June (fully shaded)



Passive Wall Legend.

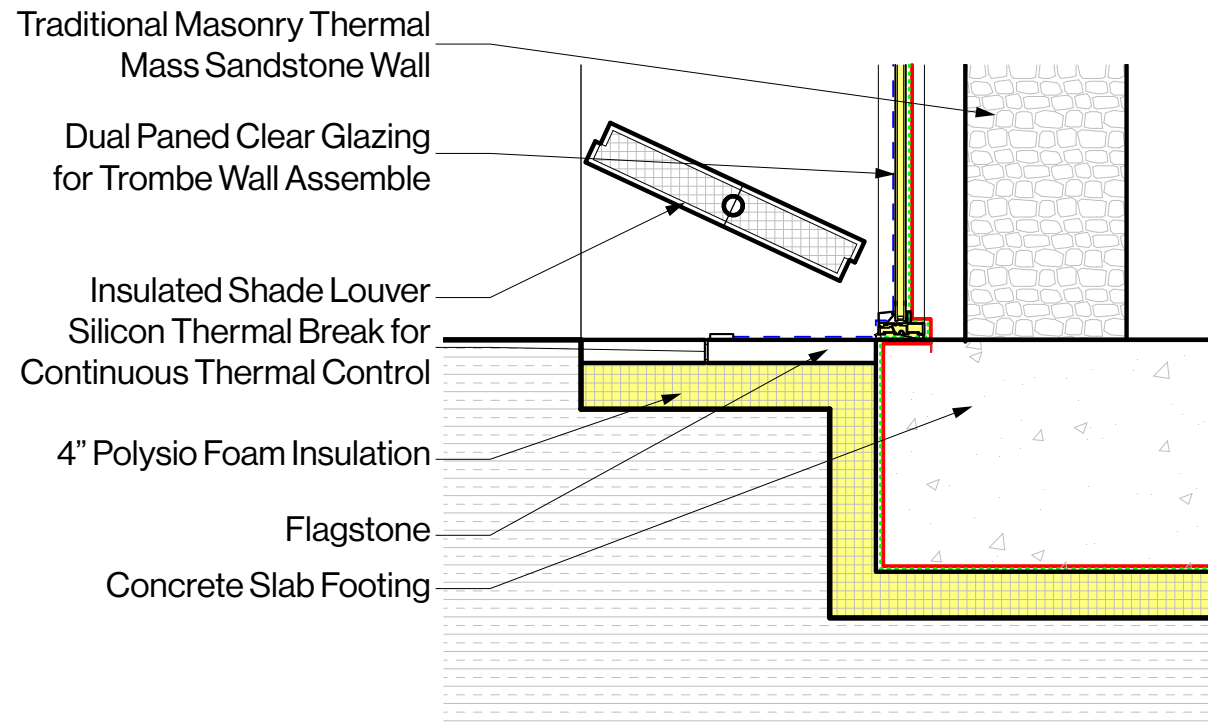
- | | | |
|---------------------------------|------------------------------|-------------------|
| A - Sandstone Thermal Mass Wall | E - Rotating Louvers | I - Insect Screen |
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| D - Air Chamber | H - Zinc Panels | |

PASSIVE WALL / details

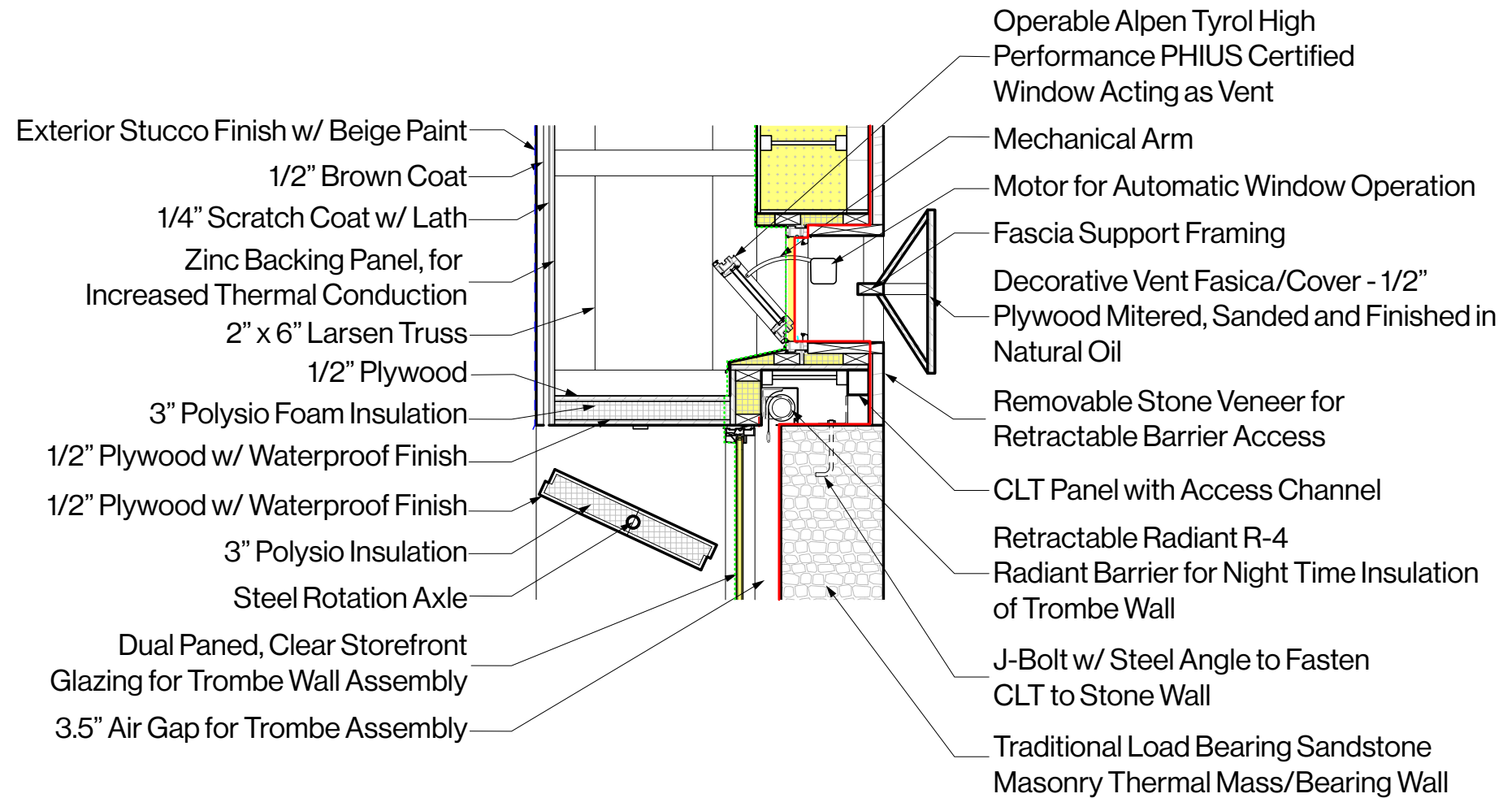


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Trombe Wall Footing Detail



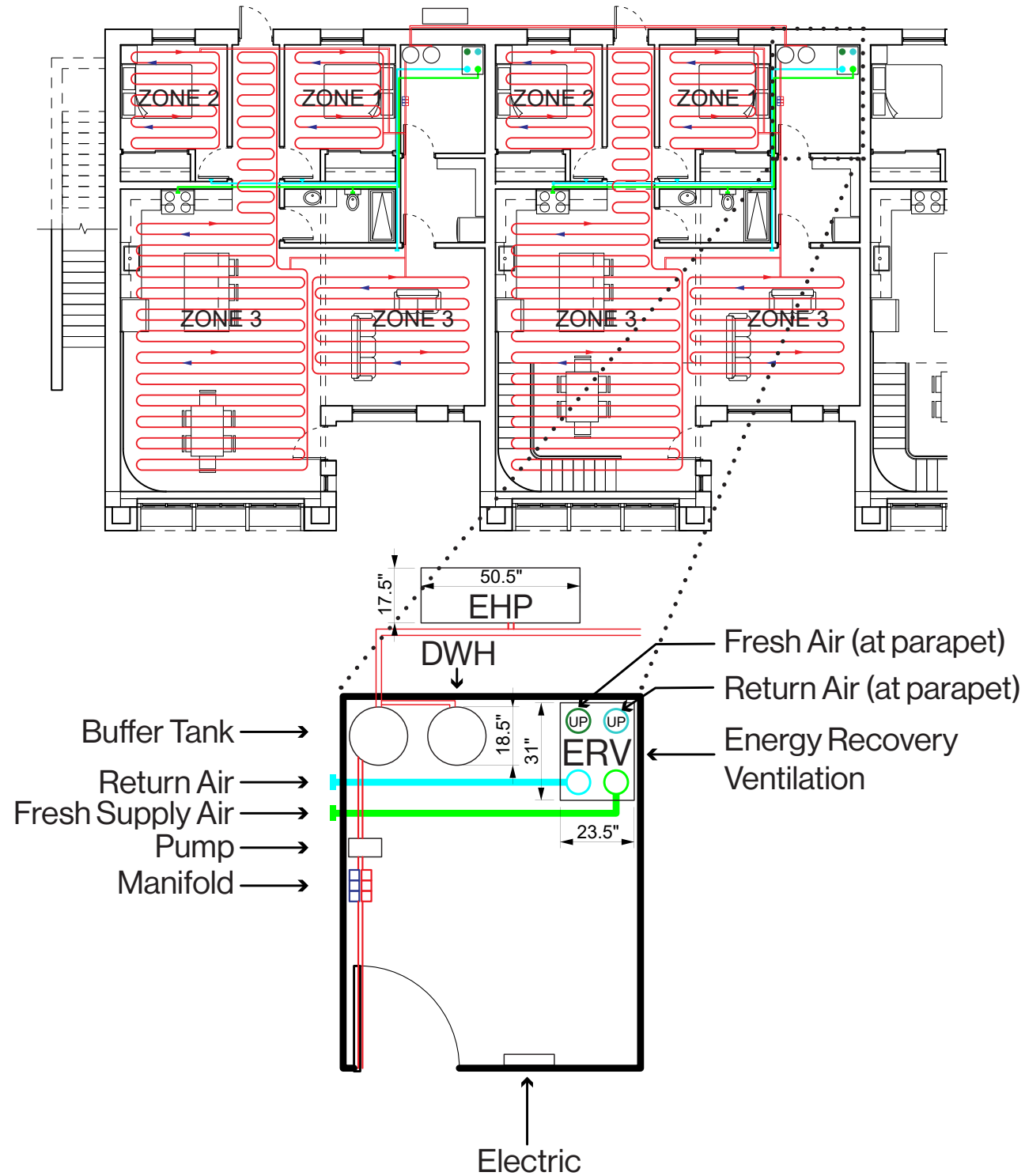
Trombe Wall Vent Detail

SYSTEMS / mechanical

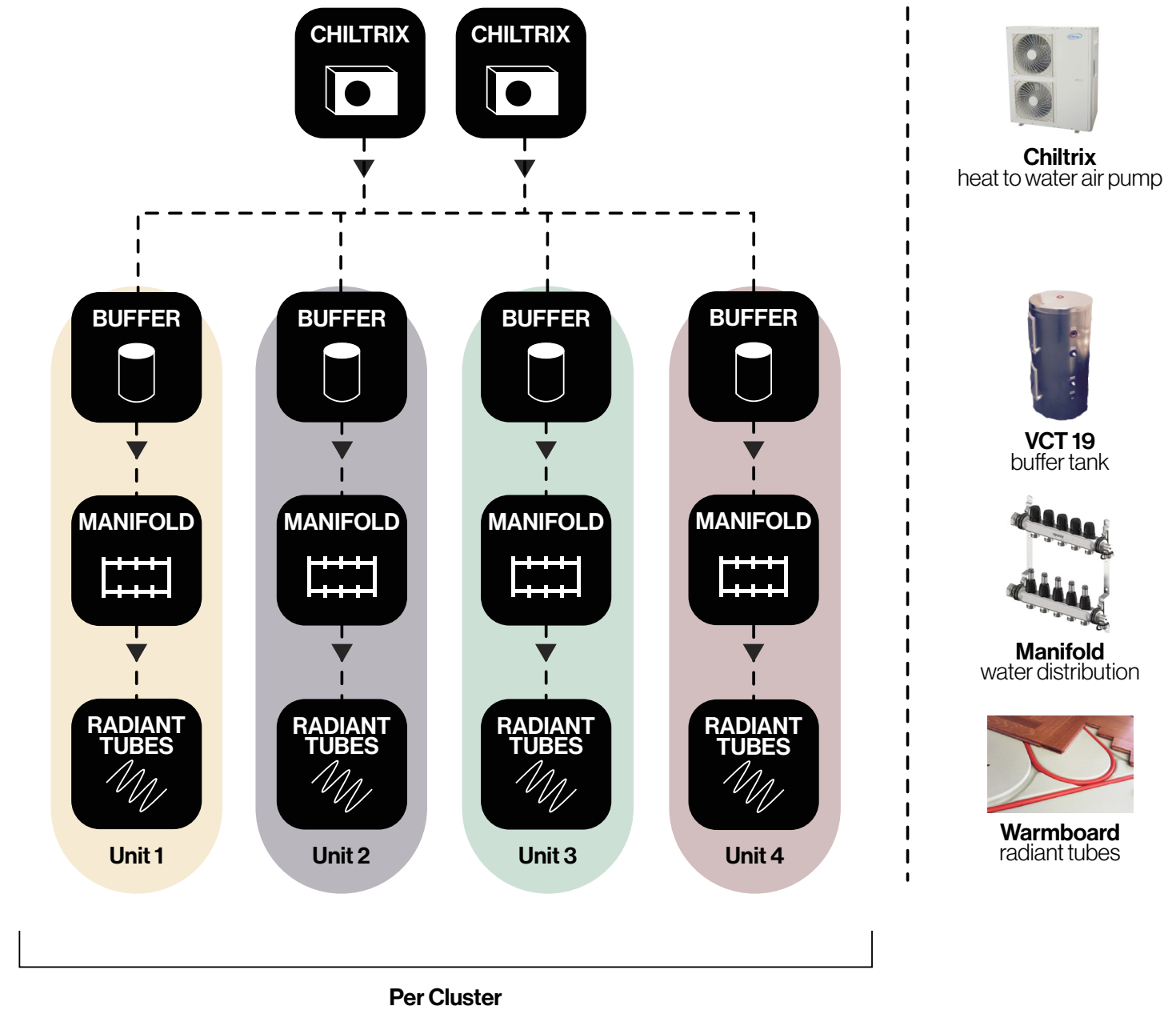


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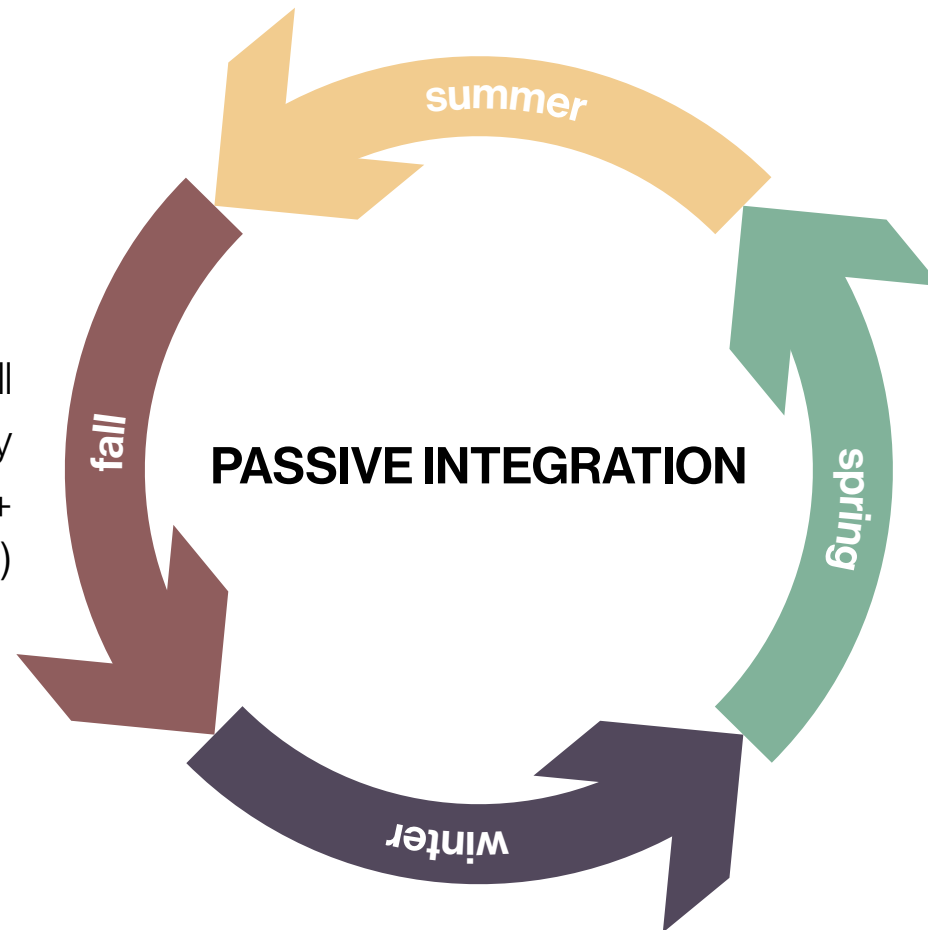
Radiant Heat/Cooling Flow Chart.



SYSTEMS / integration



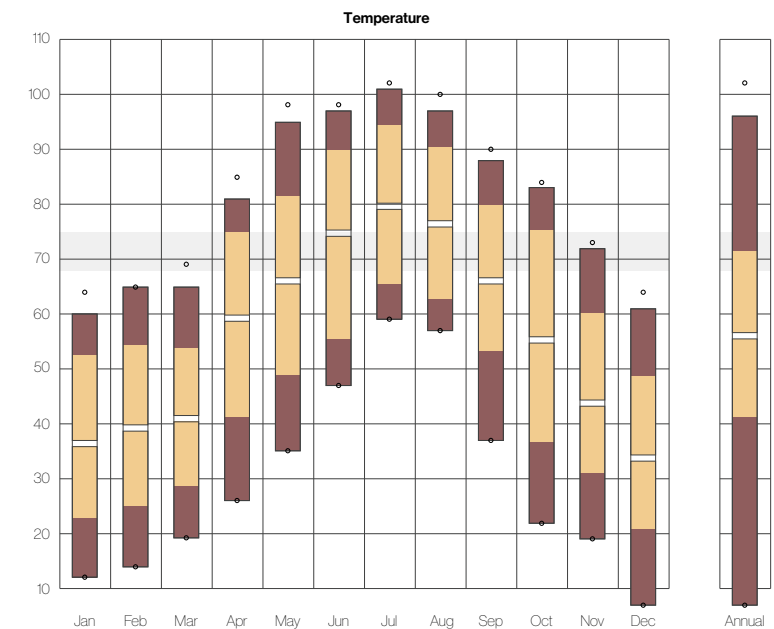
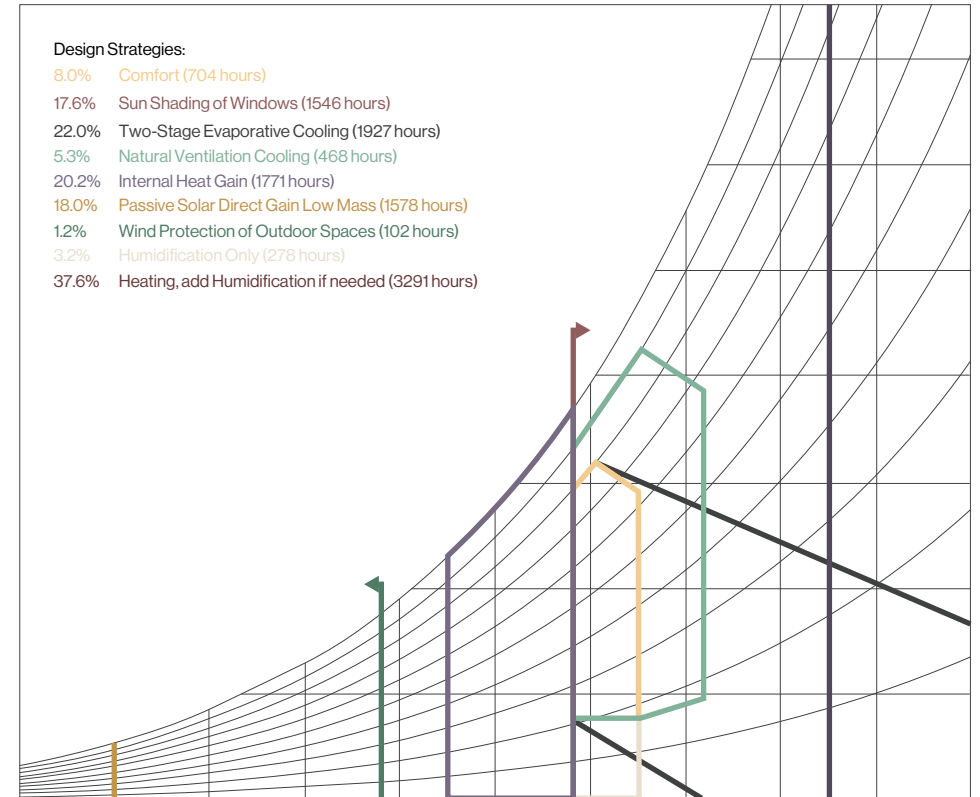
heating: none
cooling: solar chimney open(morning + evening) + radiant cooling(daytime) + closed louvers
ventilation: solar chimney(night flushing) + ERV (daytime)



heating: trombe wall
cooling: solar chimney
ventilation: solar chimney + ERV (night time)

heating: trombe wall
cooling: solar chimney
ventilation: solar chimney + ERV (night time)

heating: trombe wall + radiant + closed louvers(night time)
cooling: none
ventilation: ERV



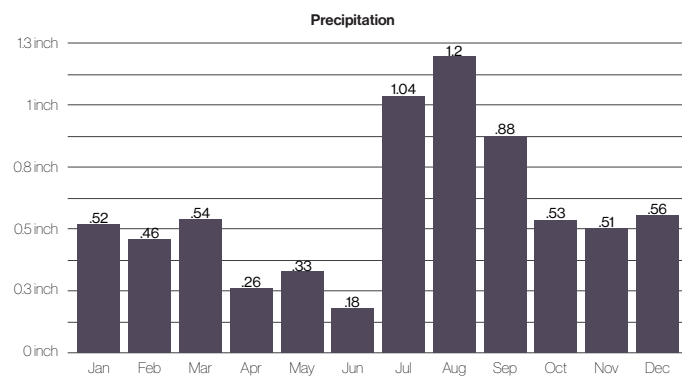
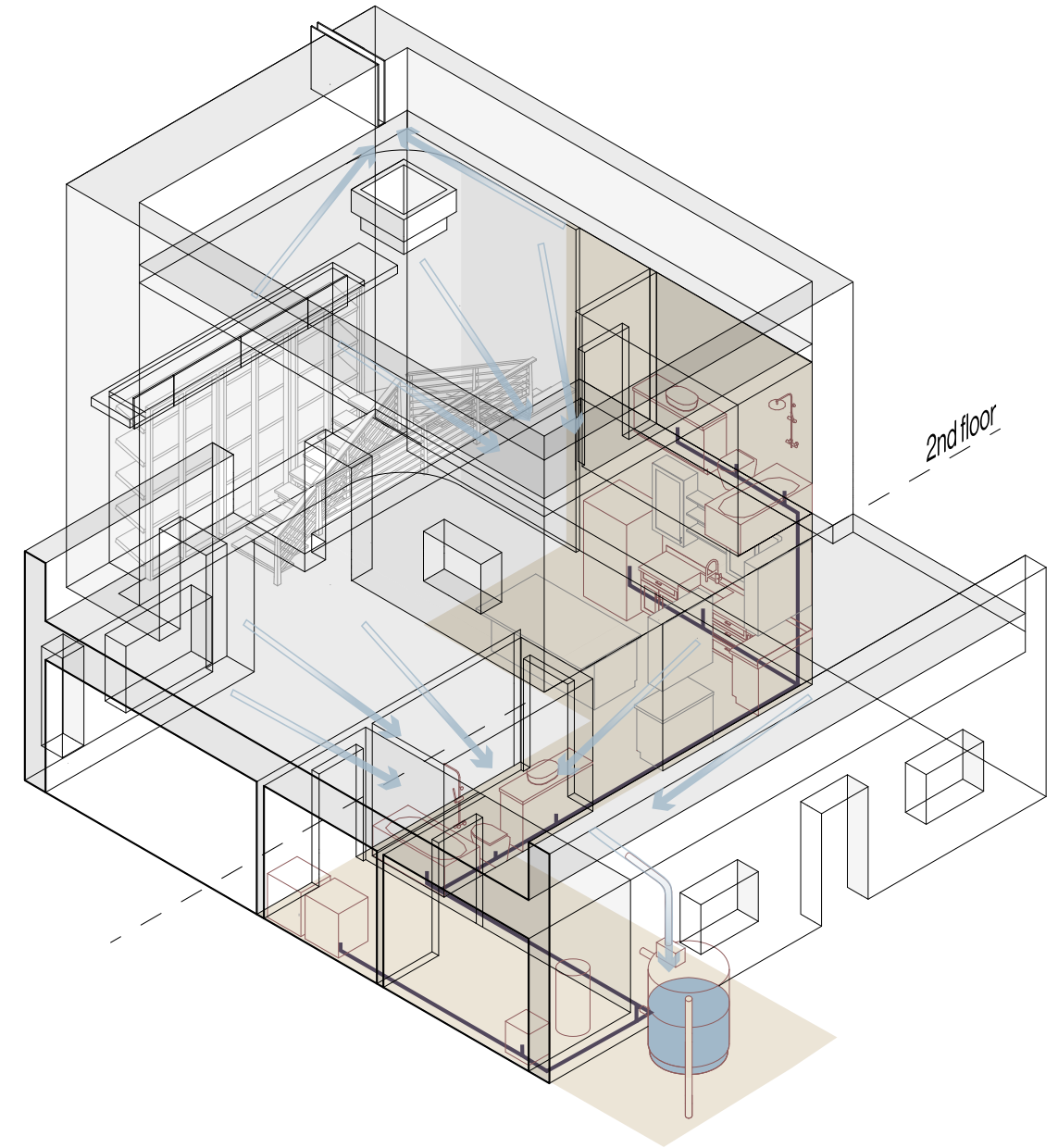
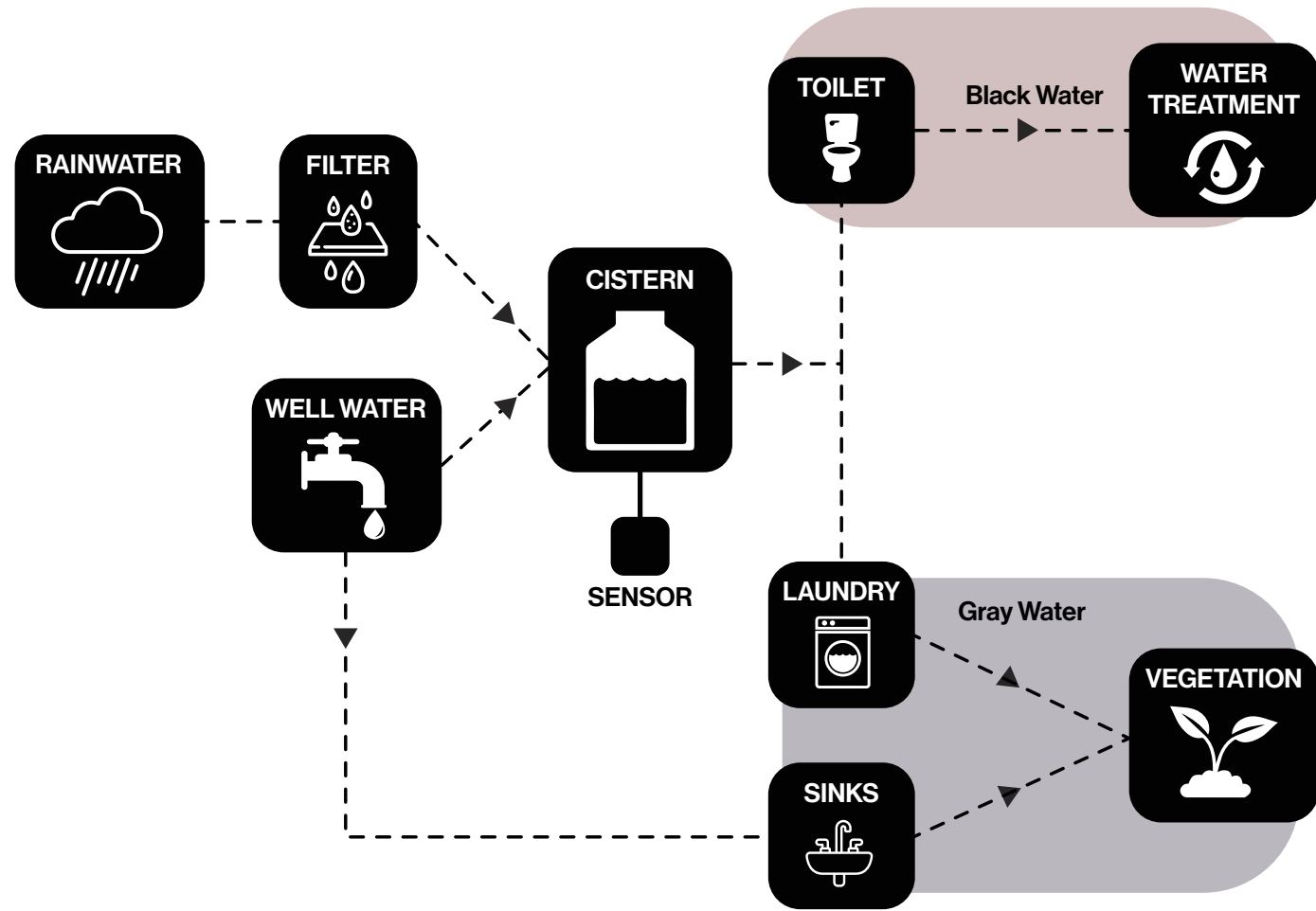
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WATER CONSCIOUSNESS / + plumbing



Water Efficiency Flow Chart.



6,000 /gallons harvested per unit.
23,000 gallons per cluster.

- Plumbing Distribution
- Plumbing Fixtures
- Roof Runoff
- Specified Distribution

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ARCHITECTURE

ENGINEERING

ENVELOPE

EFFICIENCY

GRID-INTERACTIVITY

LIFE-CYCLE

HEALTH

MARKET

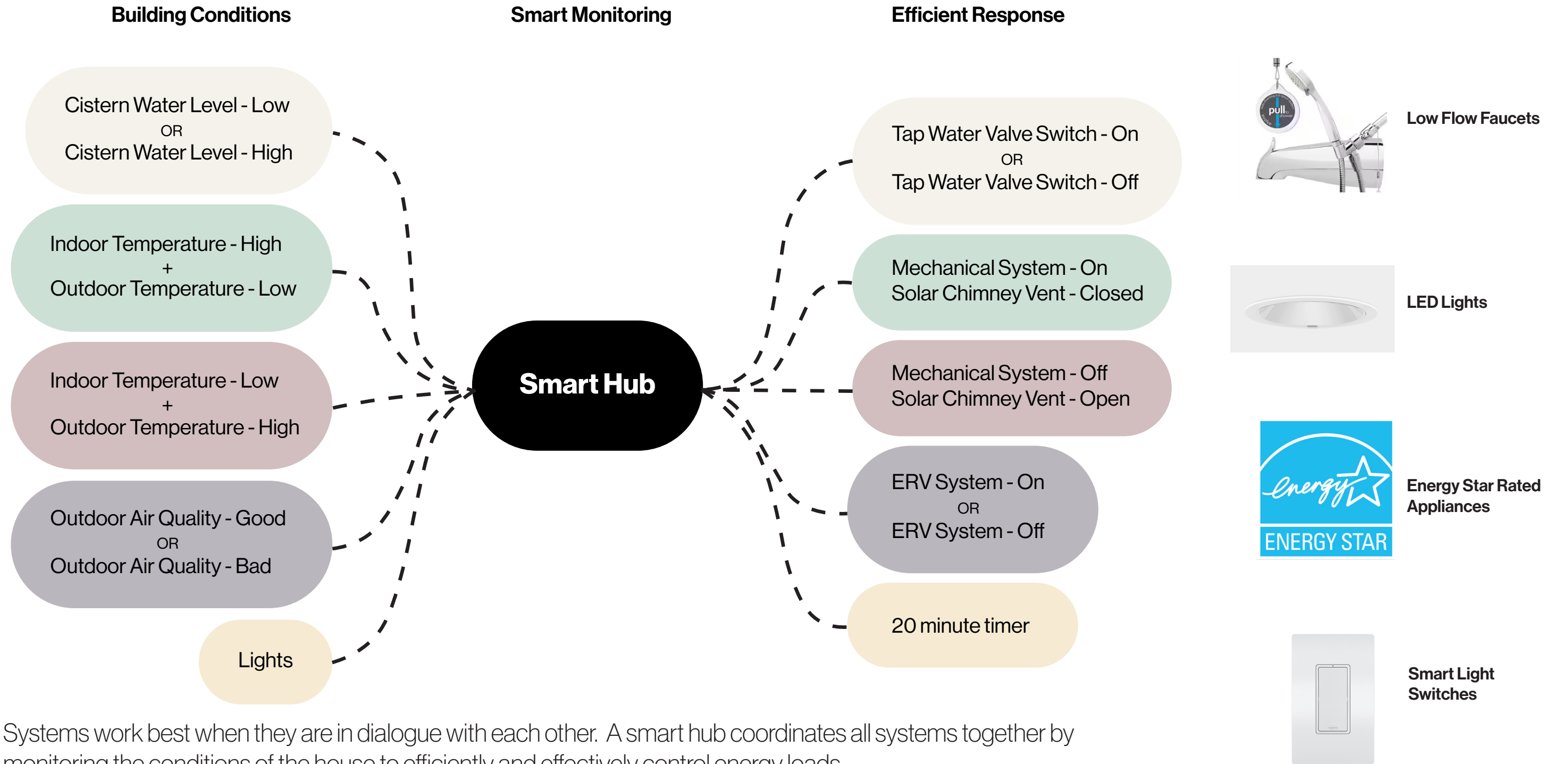
COMMUNITY

AUTOMATION / systems efficiency



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Systems work best when they are in dialogue with each other. A smart hub coordinates all systems together by monitoring the conditions of the house to efficiently and effectively control energy loads.

PHOTOVOLTAICS / energy onsite

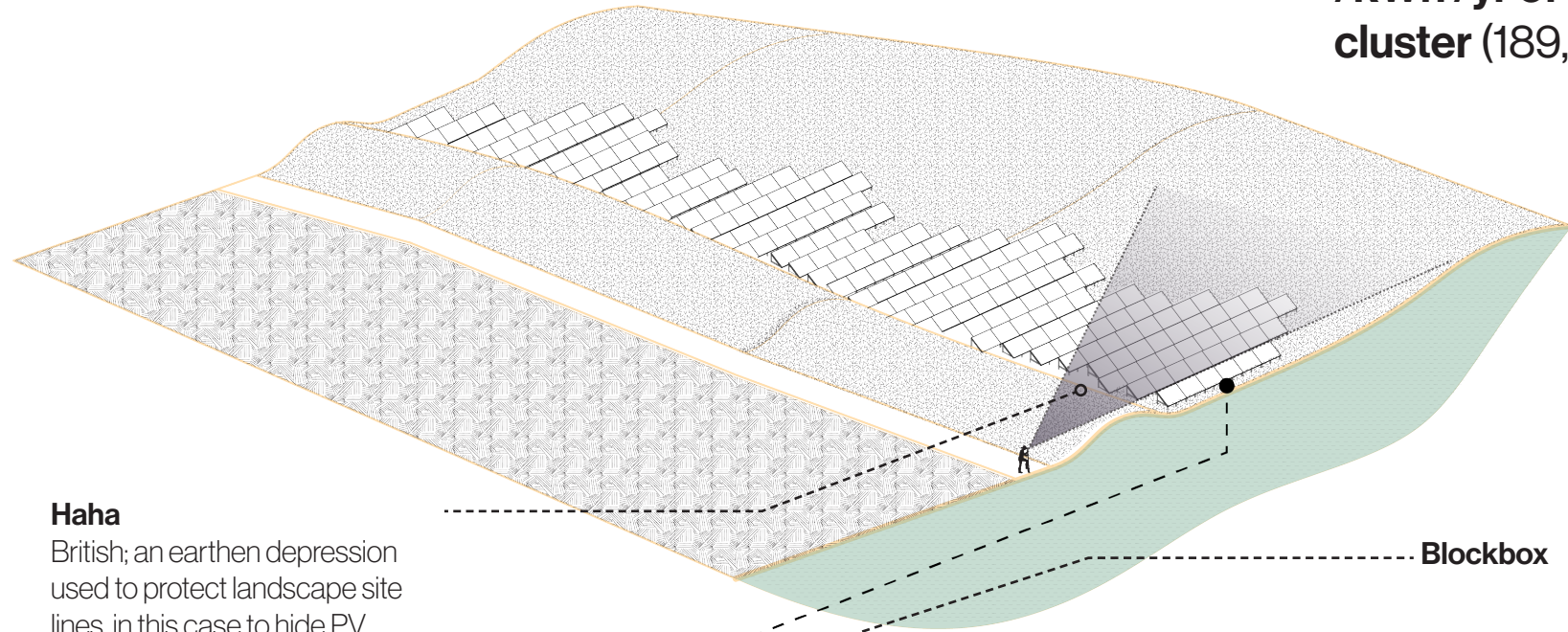


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31,566

/kWh /yr of energy generated per cluster (189,396 kWh/yr total)

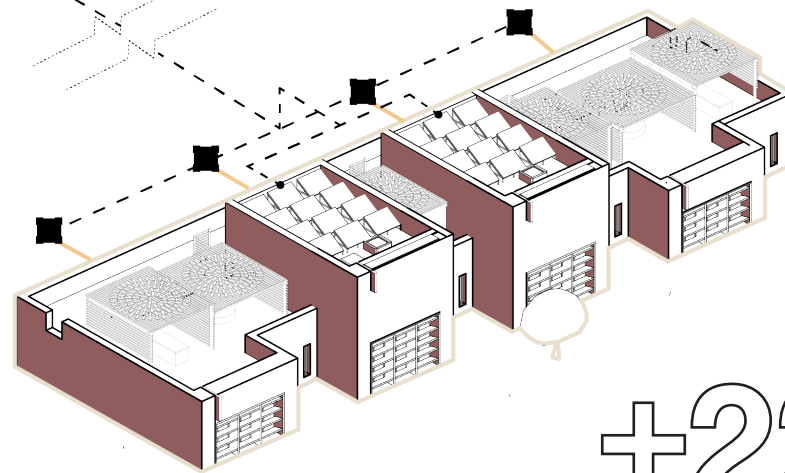


Haha
British; an earthen depression used to protect landscape site lines, in this case to hide PV.

Blockbox

9,470

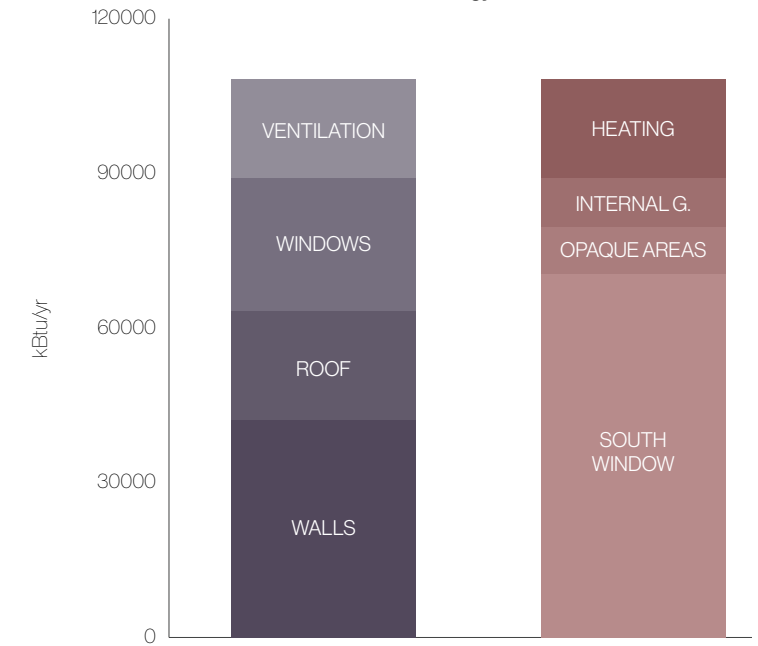
/kWh /yr of energy used in cluster



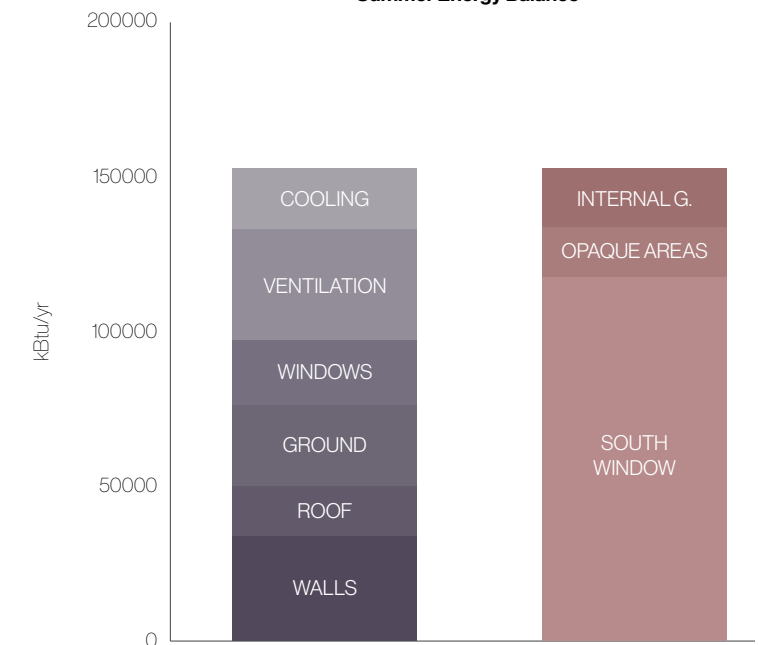
+22,088

/kWh/yr of energy surplus to be stored per cluster (132,528 kWh/yr total)

Winter Energy Balance



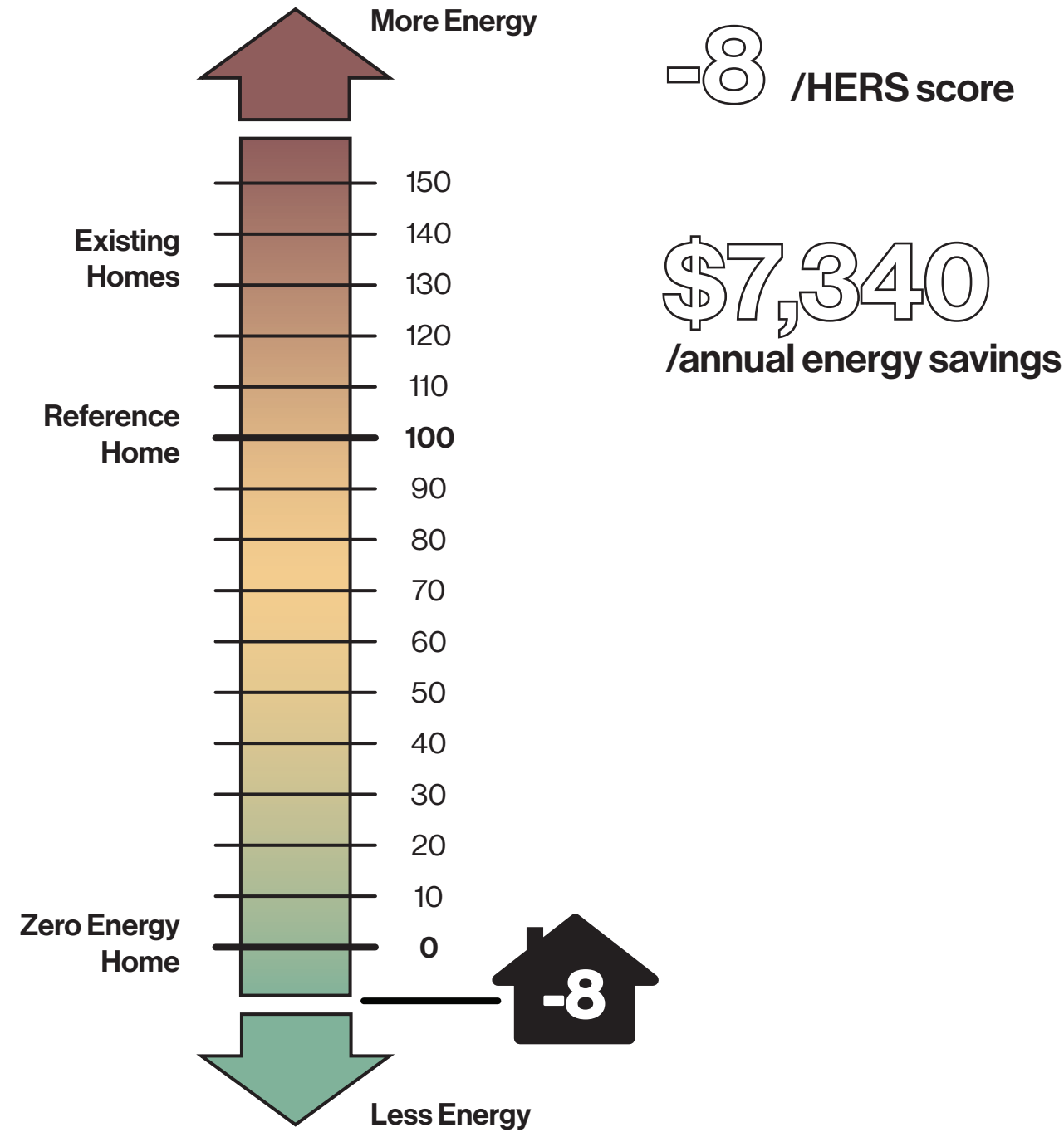
Summer Energy Balance



ENERGY EFFICIENCY / net-zero ready

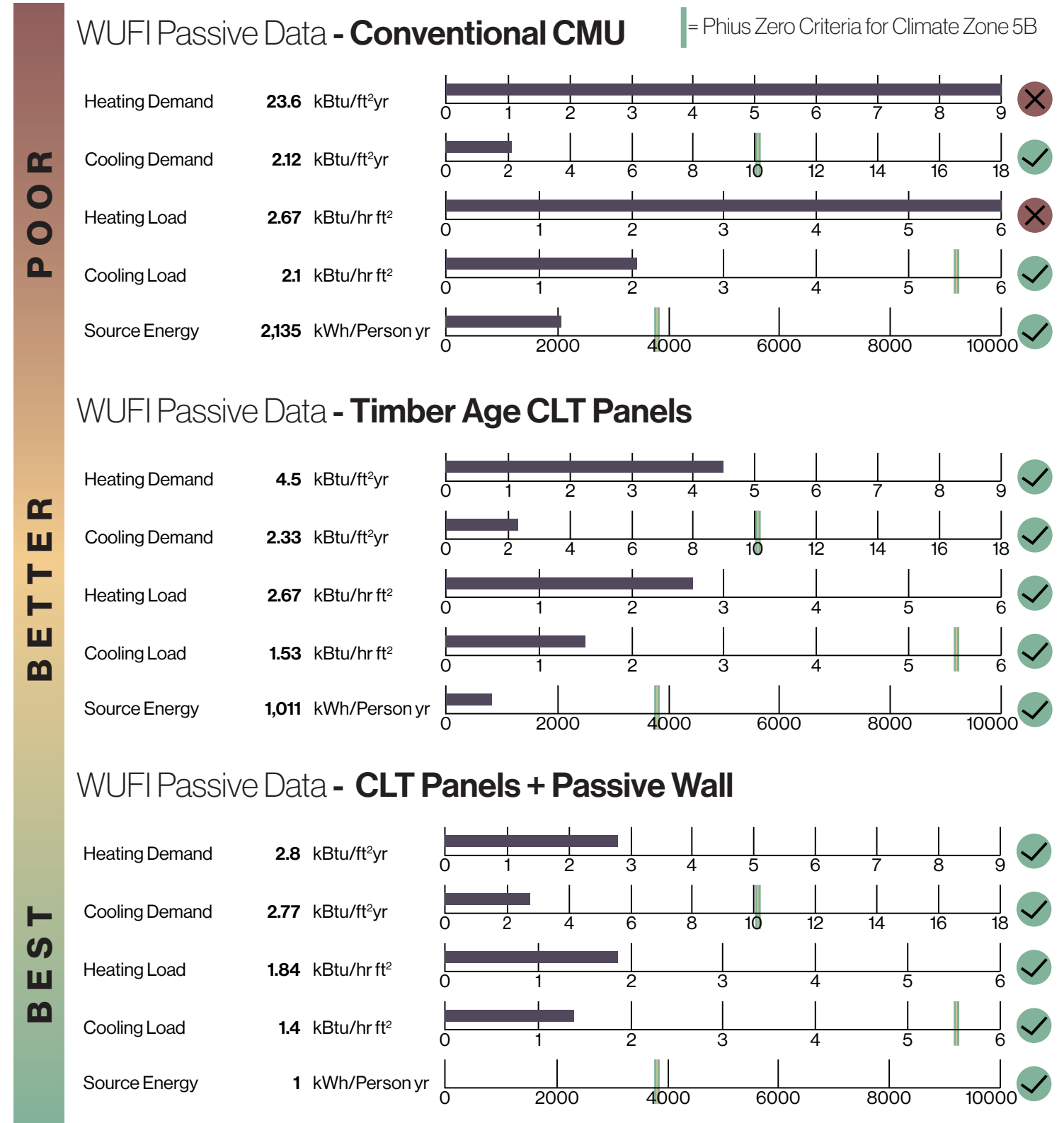


Home Energy Rating System



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CONCLUSION



“ Hopi should be a place where:

Hopi culture and religion are strong;
Sacred sites are protected;
Culturally and environmentally sensitive development occurs;
The land is looked after;
There are jobs and businesses;
Quality infrastructure serves everyone;
Everyone has their own quality house;
Public service facilities serve all needs.

”

-Hopit Tunatya’at 2000

- Remote Location away from Sacred Land
- Inclusion of ceremonial community space

CONCLUSION



“ **Hopi should be a place where:**

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Public service facilities serve all needs.

”

-Hopit Tunatya’at 2000

- **Low impact, sustainable structural wall panels.**
- **Water conservation and harvesting.**
- **Clean Energy**
- **Food Security through Dry Farming**

CONCLUSION



“ **Hopi should be a place where:**

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development occurs;
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**Quality infrastructure serves
everyone;**
Everyone has their own quality house;
Public service facilities serve all needs.

”

-Hopit Tunatya’at 2000

- **Re-introducing sandstone walls brings back traditional Hopi masonry jobs.**
- **Pre-fabricated assemblies allows the Hopi to participate in the construction process.**
- **Block Energy Micro-grid gives energy sovereignty to the Hopi**

CONCLUSION



“ **Hopi should be a place where:**

Hopi culture and religion are strong;
Sacred sites are protected;
Culturally and environmentally sensitive development occurs;
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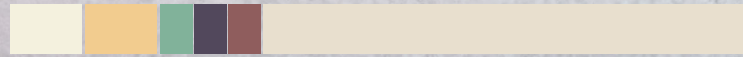
”

-Hopit Tunatya’at 2000

- Net-zero condominiums

-Designed appropriately for climate and environment

CONCLUSION



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[CABANILLAS . MOODAY . NELSON . PEREA . WEST]



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ACKNOWLEDGEMENTS



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- CPHC (Phius Certified Consultant)

Laura Carr

- Native Peoples Design Coalition Founder

Greg Veitch

- Drachmann Institute Research Coordinator

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