Al Hijla Vertical Farm

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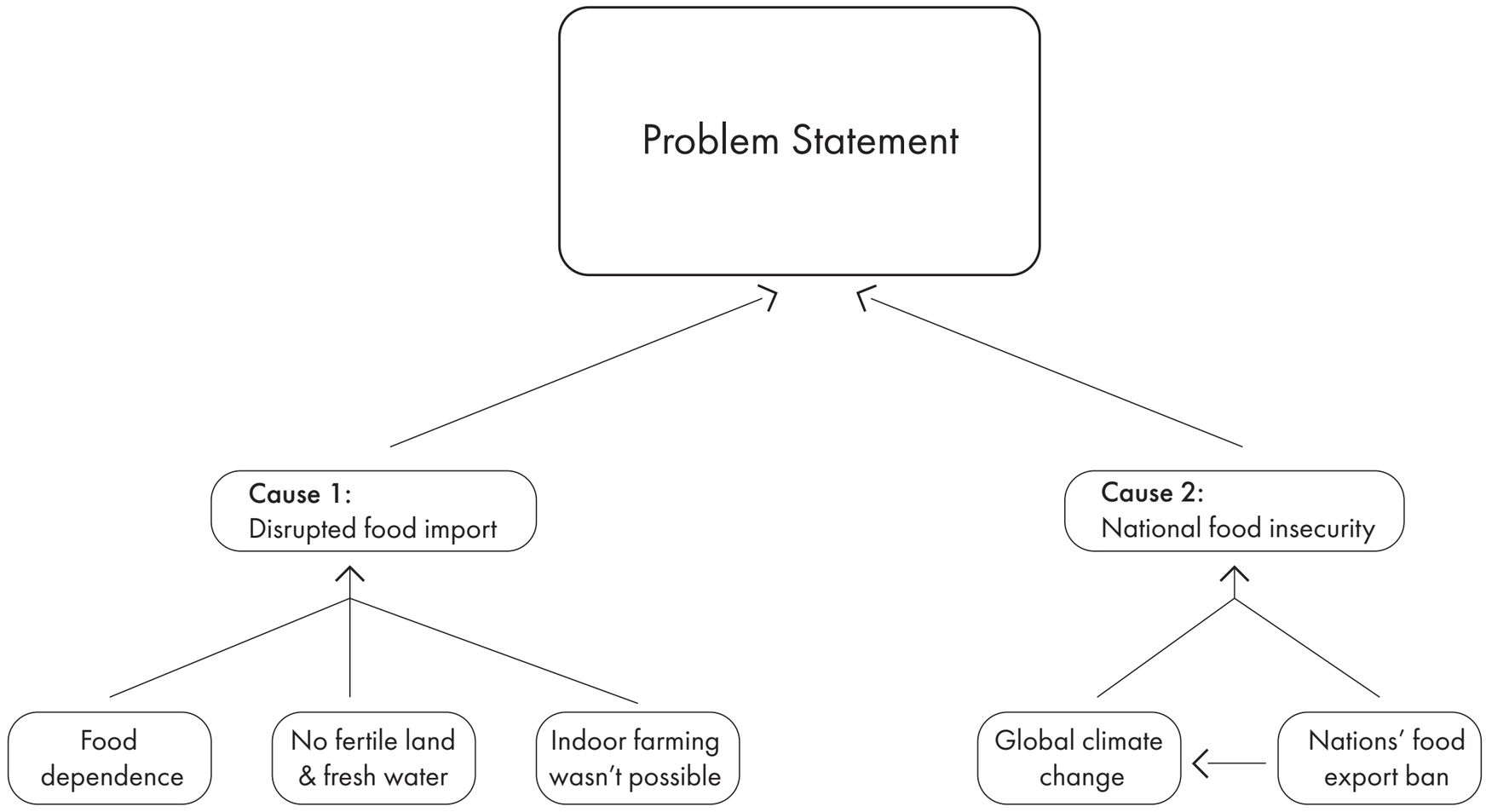
Architectural Engineering Graduation Studio

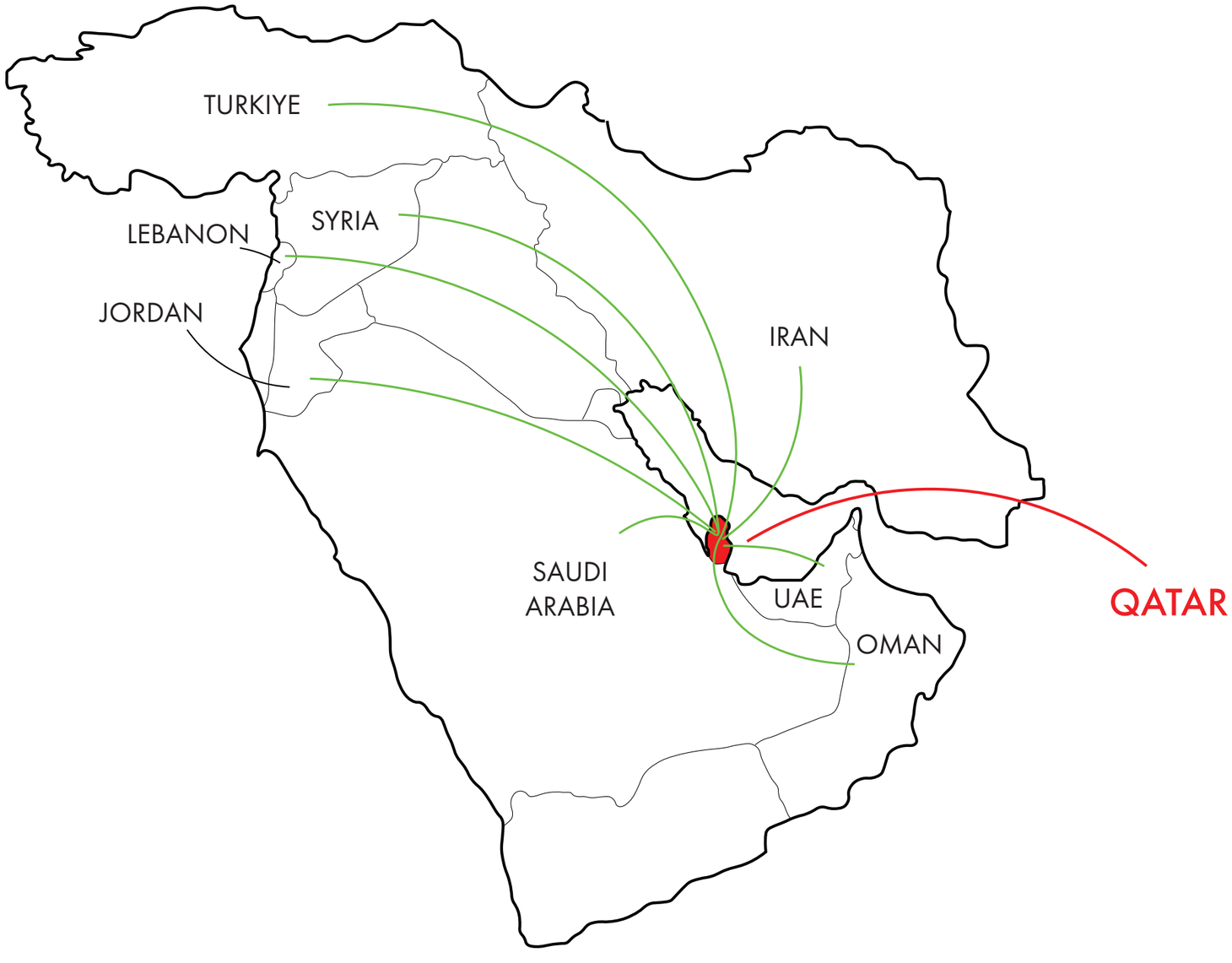
CONTENT

Problem Statement

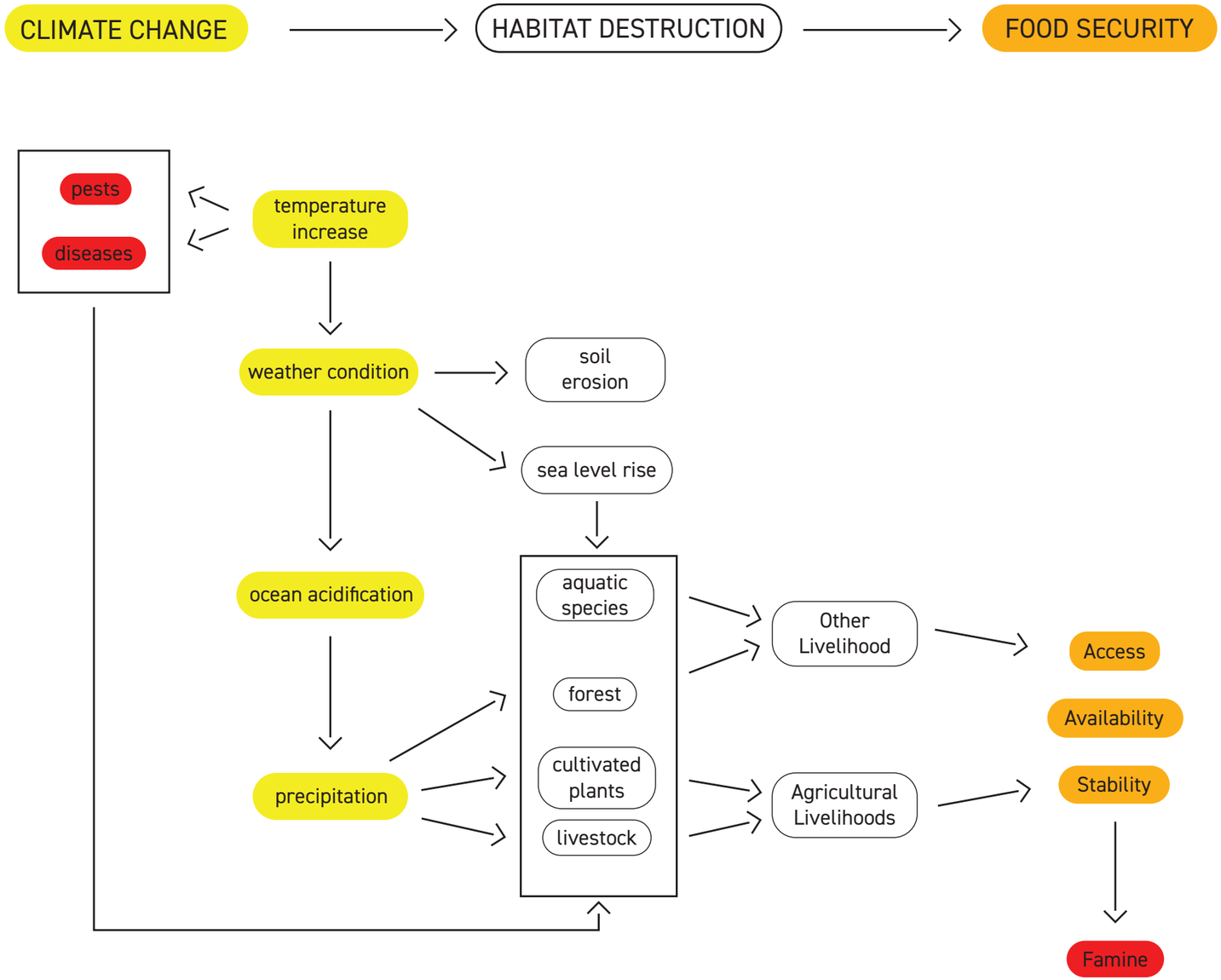
Main Causes


Problem Statement
Cause 1:
Disrupted food import
Food dependence
No fertile land & fresh water
Indoor farming wasn't possible
Cause 2:
National food insecurity
Global climate change
Nations' food export ban

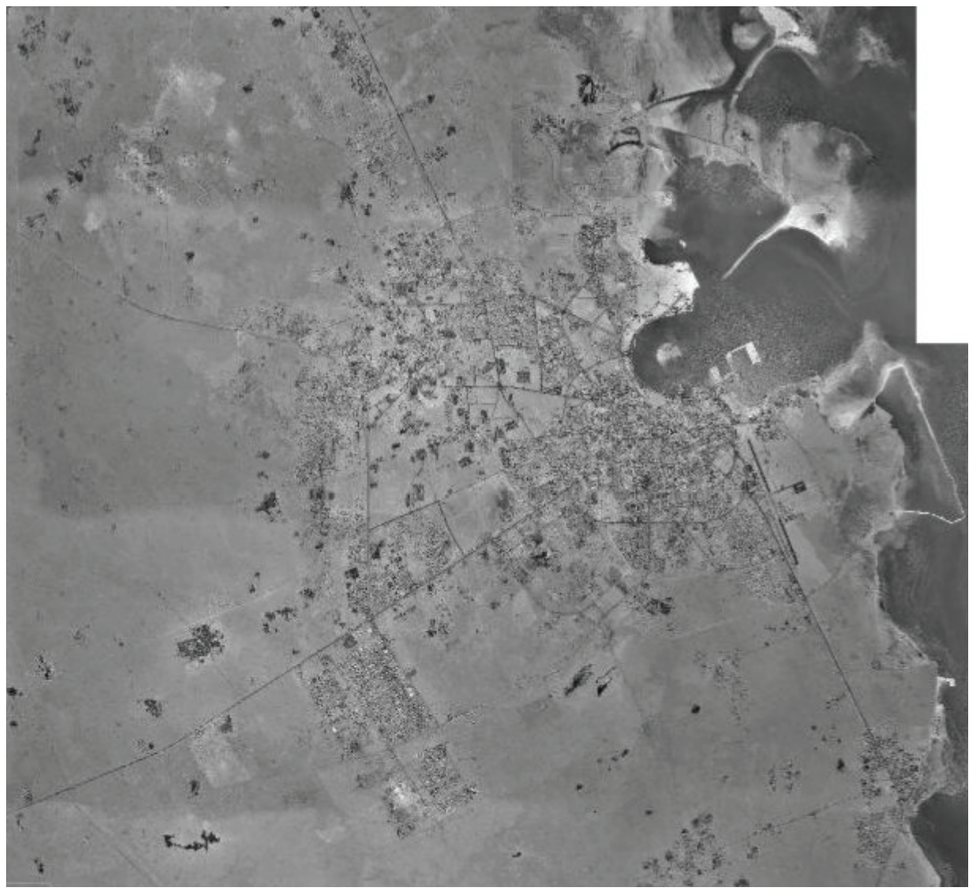
Cause 1


TURKIYE
SYRIA
LEBANON
JORDAN
IRAN
SAUDI
ARABIA
UAE
OMAN
QATAR

Cause 2


CLIMATE CHANGE
HABITAT DESTRUCTION
FOOD SECURITY
pests
diseases
temperature increase
weather condition
soil erosion
sea level rise
ocean acidification
aquatic species
forest
cultivated plants
livestock
precipitation
Other Livelihood
Agricultural Livelihoods
Access
Availability
Stability
Famine

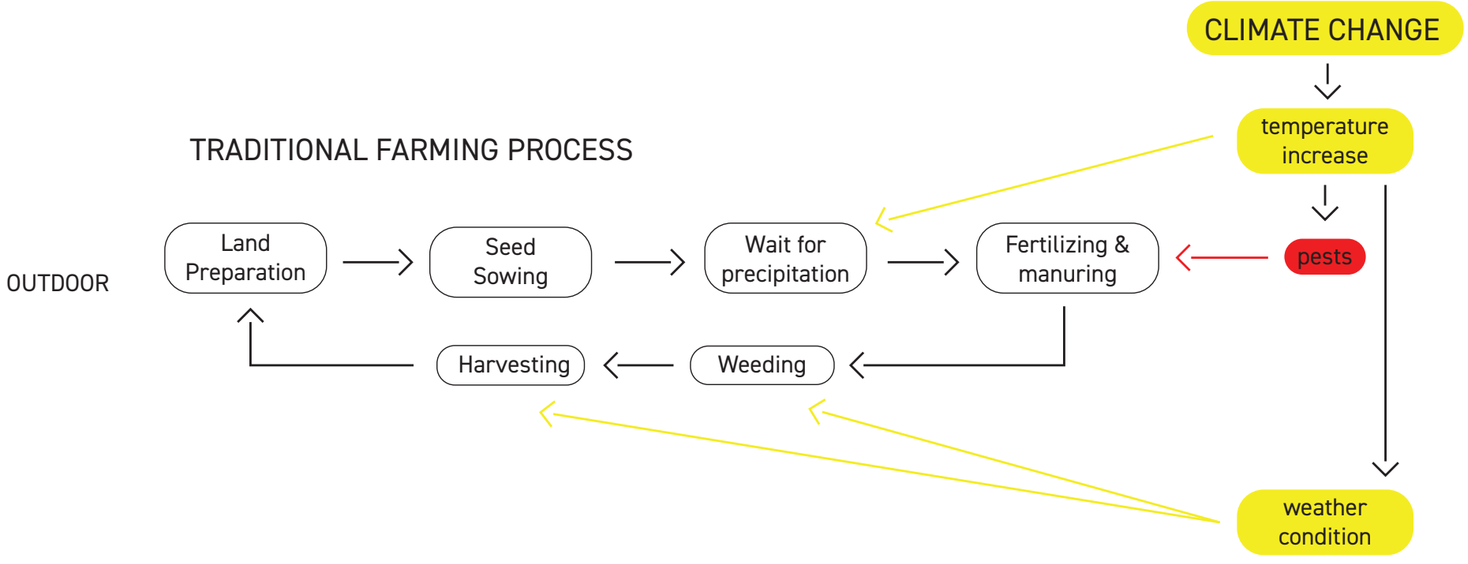
Doha Rapid Expansion

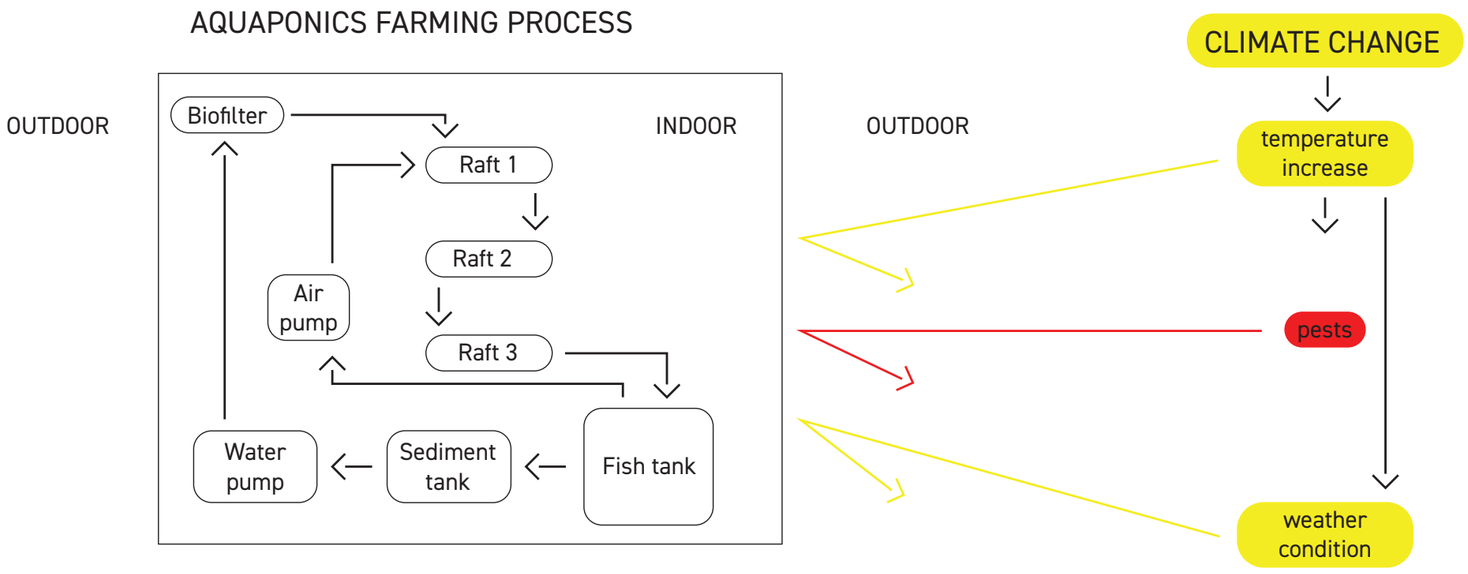


Doha 1995

Doha 2019

Traditional vs. Advanced Farming



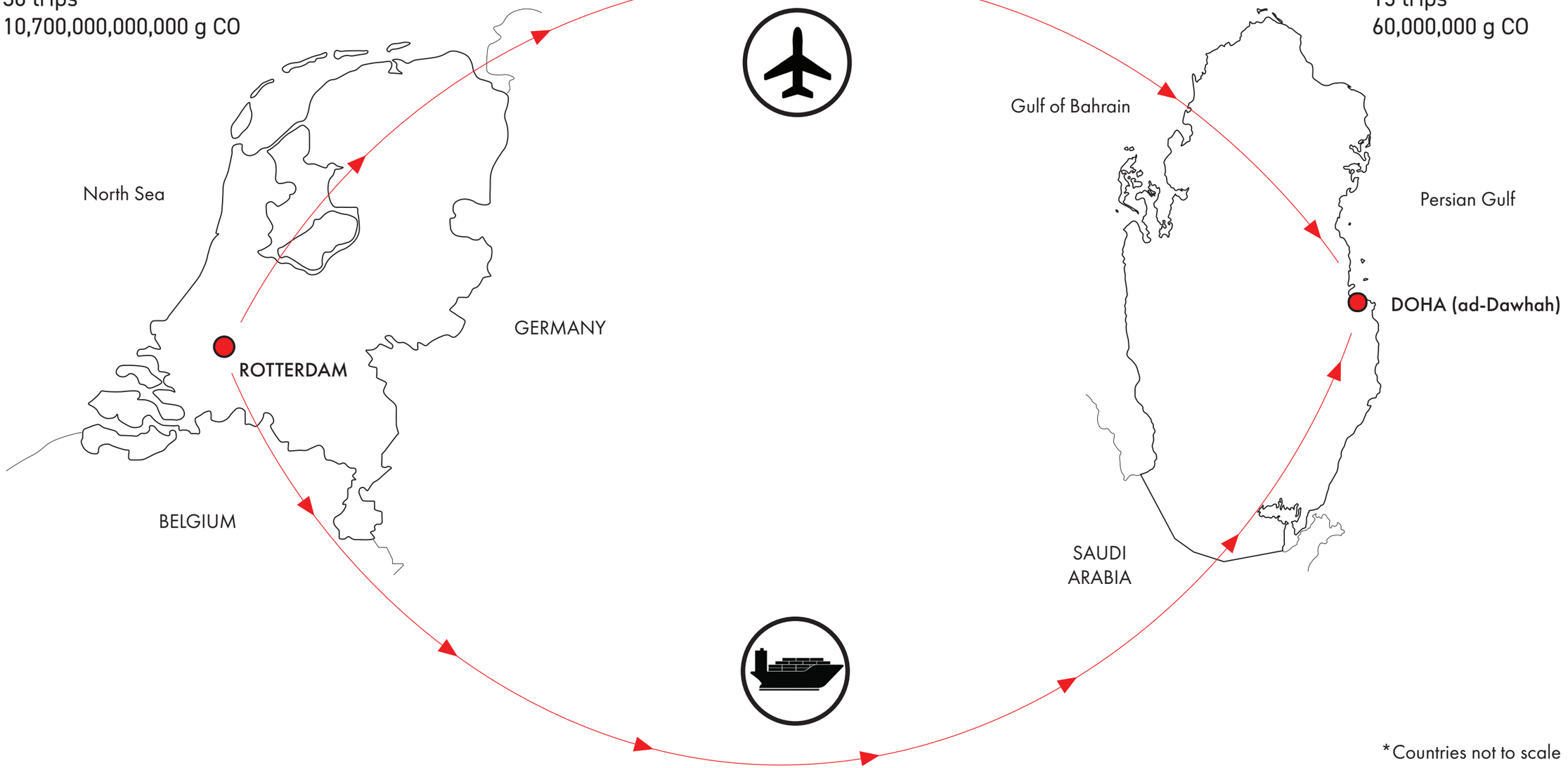


Potential Outcomes

Outcome #1

Air Freight:
4,863 km
13 hours and 25 minutes
30 trips
10,700,000,000,000 g CO

Cargo Ship:
12,294 km
36 days 19 hours
15 trips
60,000,000 g CO



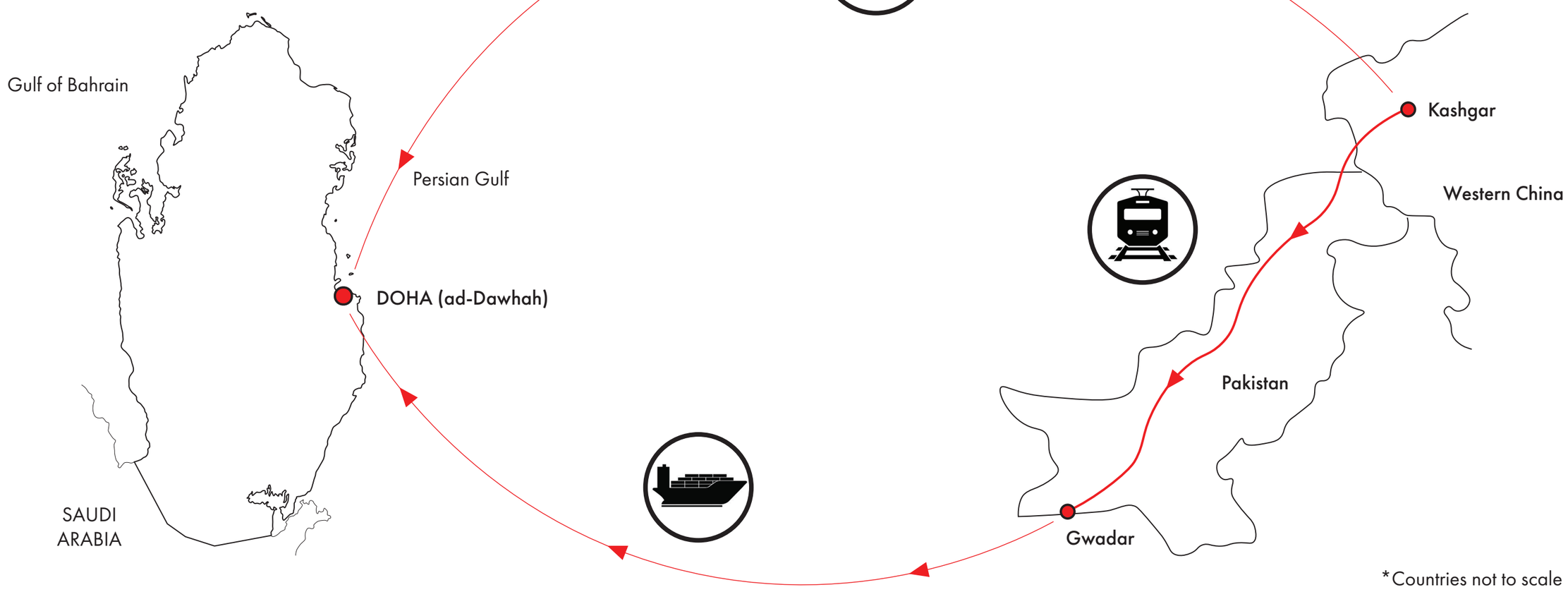
*Countries not to scale

Potential Outcomes

Outcome #2

Air Freight:
2,796 km
6 hours
30 trips
6,100,000,000,000 g CO

Train & Cargo Ship:
4,354 km
4 days
352 train trips
15 cargo trips
460,000,000,000 g CO



*Countries not to scale

Outcome #3

Option 1 - Centralized Facility

Option 2 - Within Reach

NOT Just A Vertical Farm - Automation + Humanity

Design Application

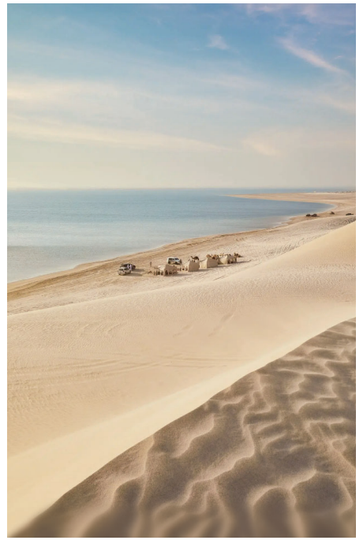
Conventional Vertical Farm

Doha Social Environment

Learning From The Past - Arab Urban Grain & Qatar Identity

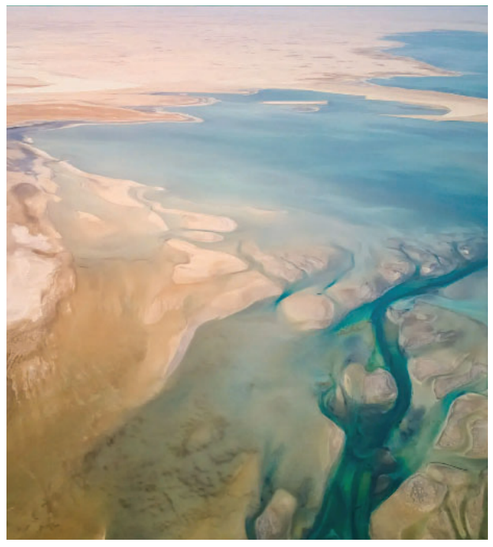
Qatar Natural Environments

Beach



Inland Sea

Jebels



Wadi and Runnel

Rawdah and Sinkholes

Photos taken by Visit Qatar

Qatar Architectural Characteristics







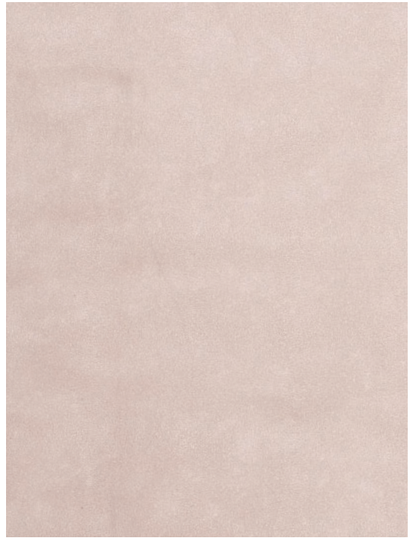
Photos taken during site visit

Qatar Identity

Photos taken during site visit

Qatar Local Materials Identities



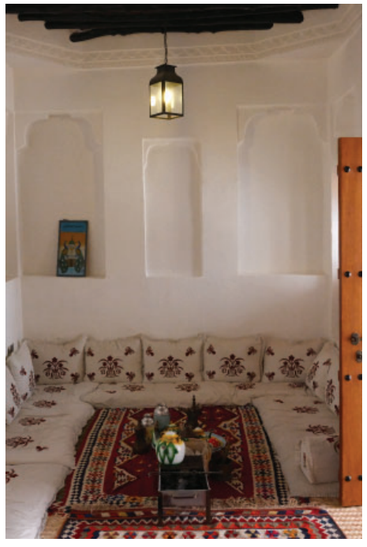



Photos taken during site visit

Building Techniques





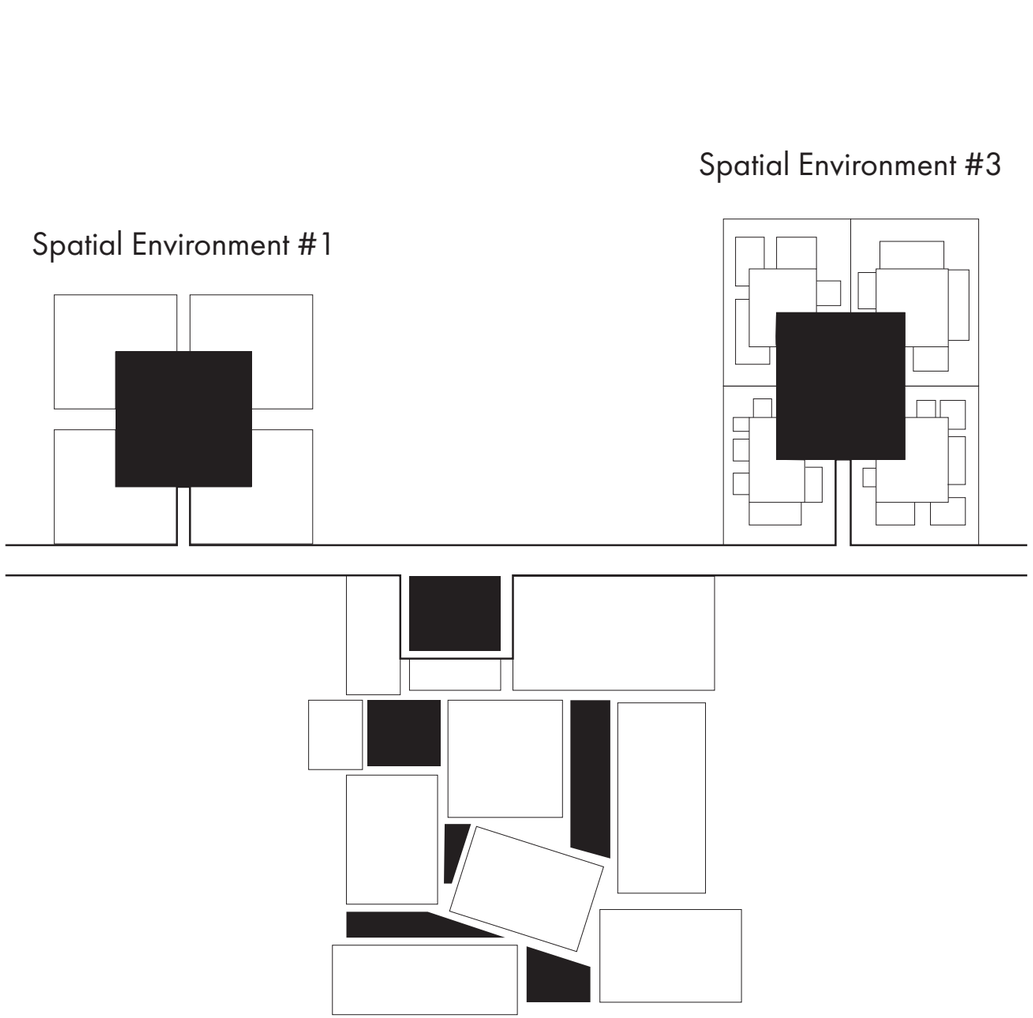




Photos taken during site visit

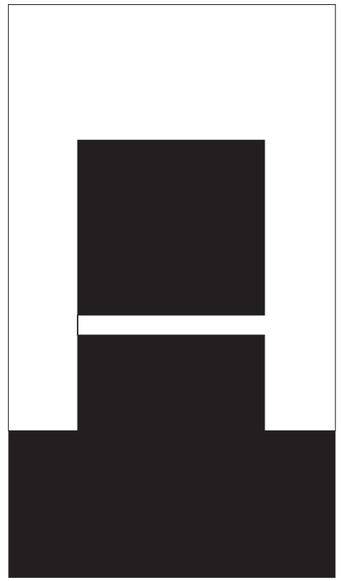
Spatial Environments

Spatial Environment #1

Spatial Environment #3



Spatial Environment #2



Spatial Environment #4

Principles of Arab Urban Grain:

1. Diversity in Spatial Environments,
2. Unity in Materials,
3. Urban Layout Form and Geometry,
4. Aspect of Home,
5. Aspect of Street,
6. Designing for climate

Site Research & Analysis

Site Focus

Vacant Locations

Thesis Location

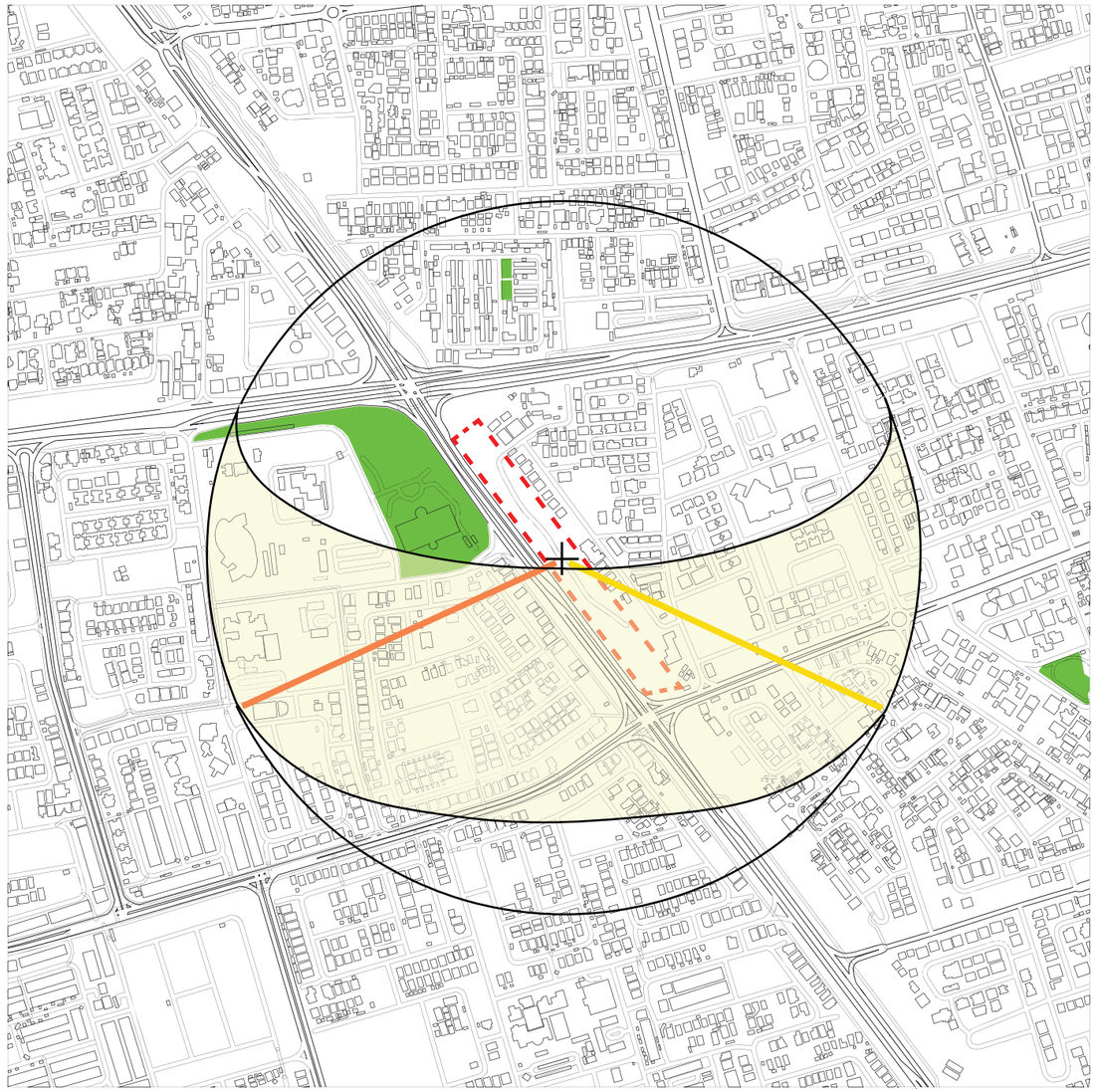
N

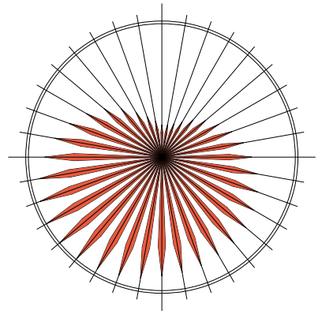
2000m

5000m

Site Research & Analysis

Winter Sun Characteristics Study

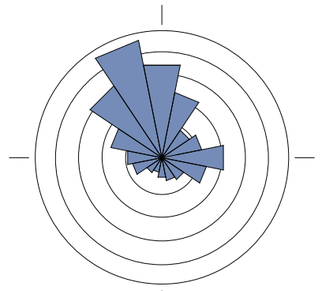




January 1 Sun Direction

Sunrise - 6:20 am

Sunset - 16:55 pm

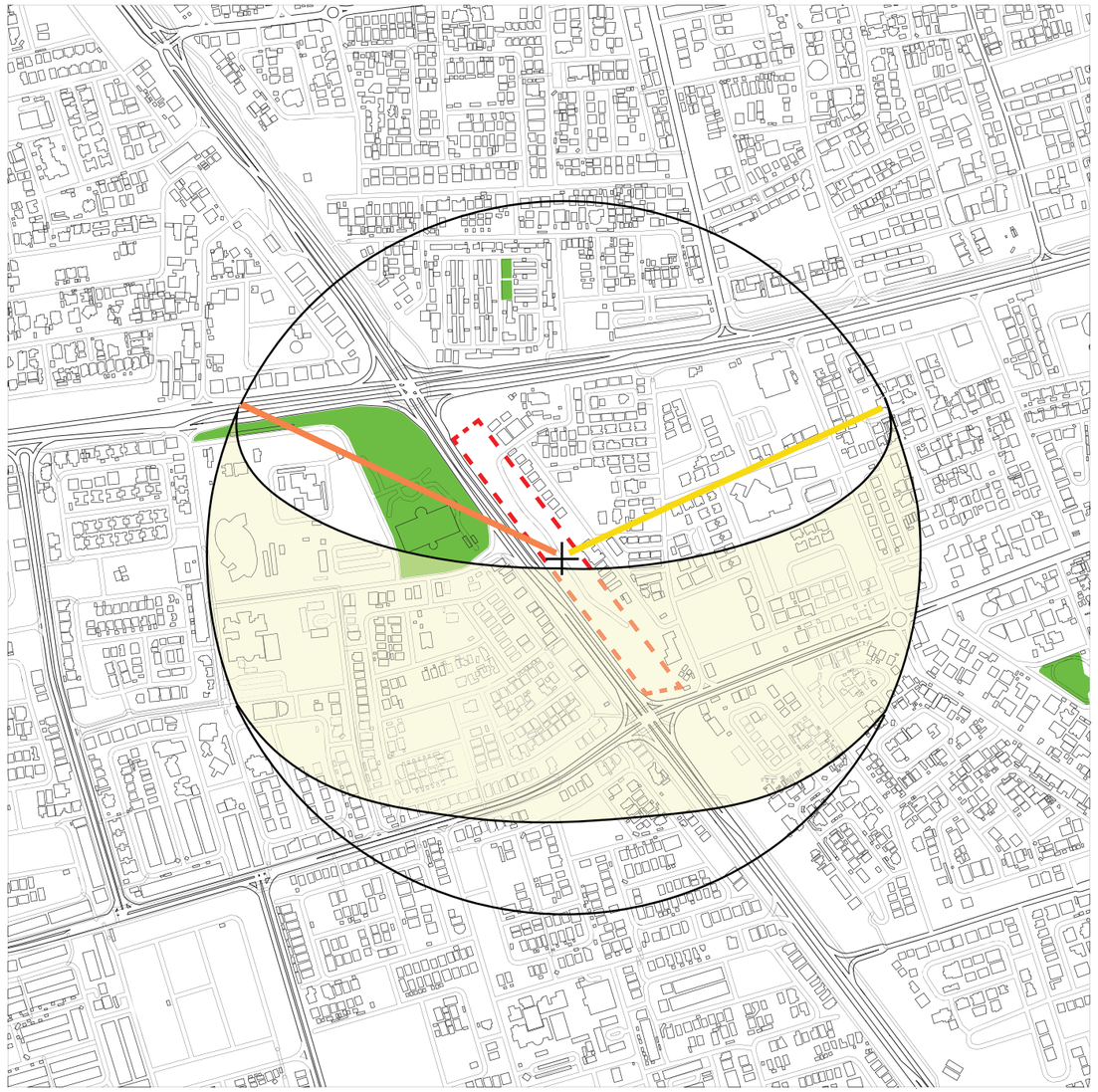


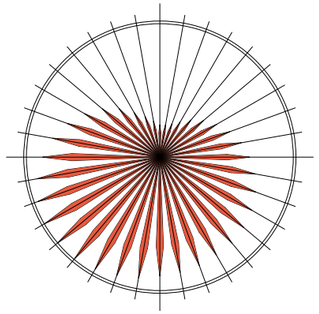
N

500m

Site Research & Analysis

Summer Sun Characteristics Study

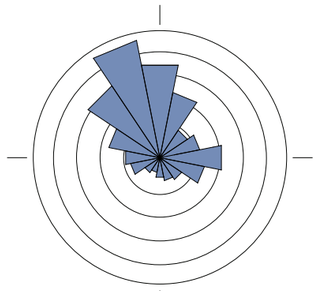




June 1 Sun Direction

Sunrise - 4:44 am

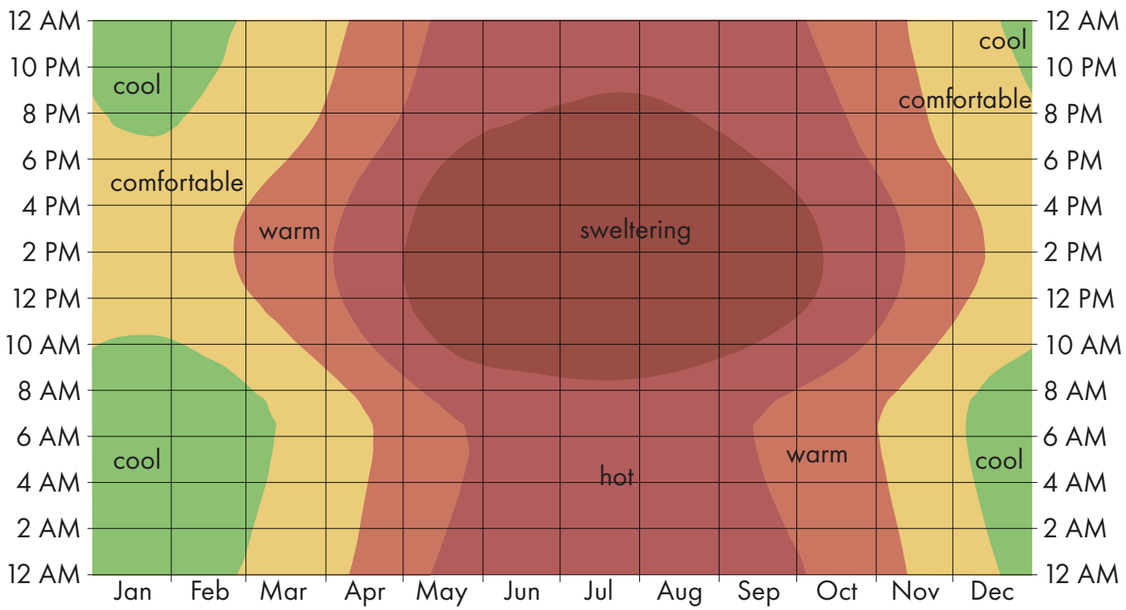
Sunset - 18:21 pm

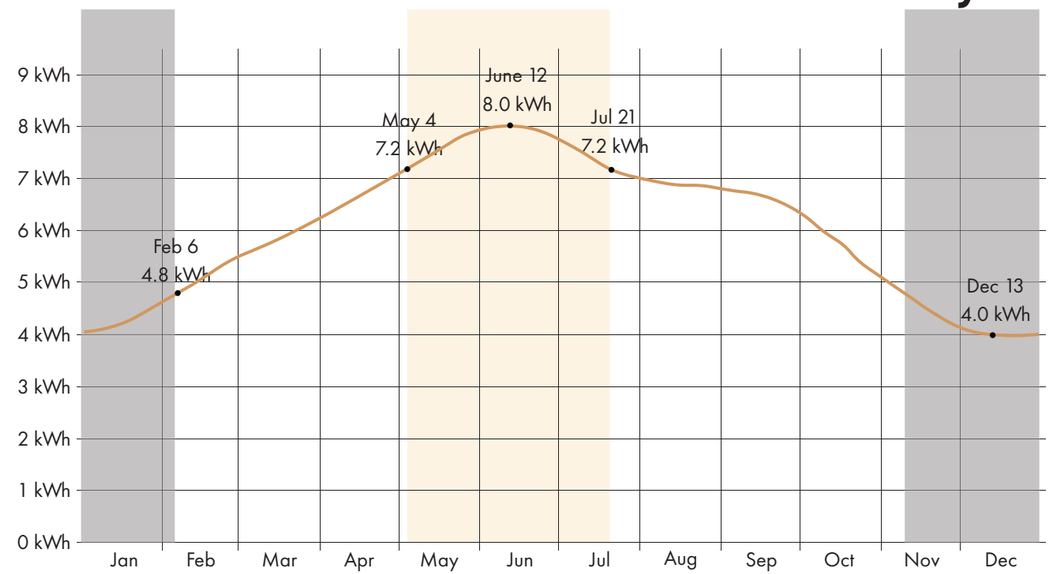


N

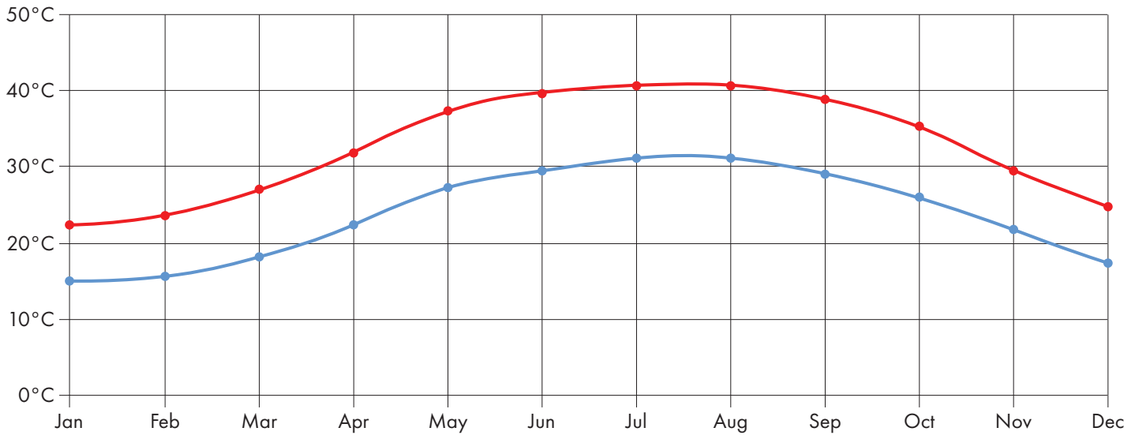
500m

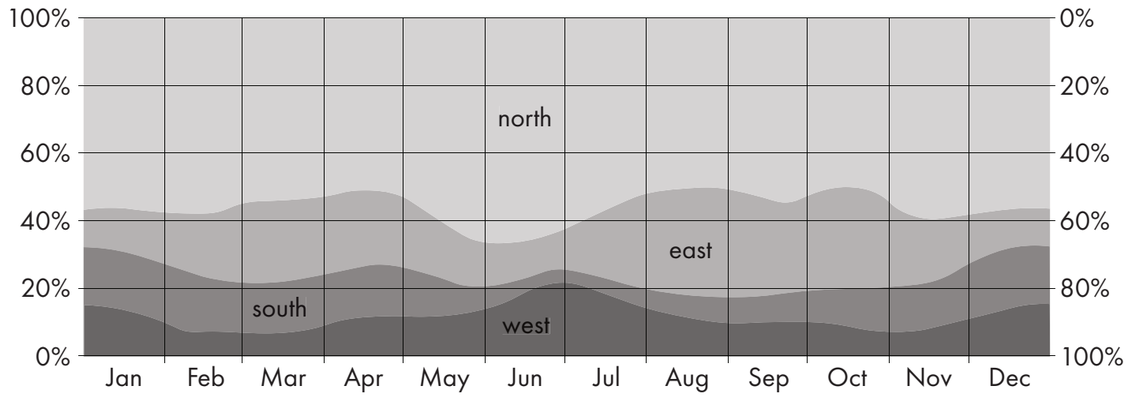
Annual Outdoor Climate & Wind Analysis



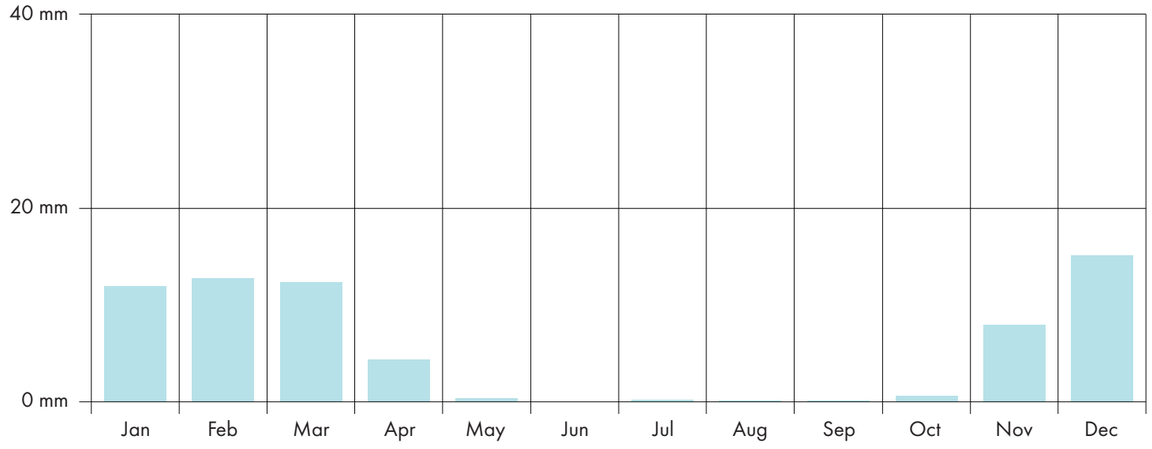


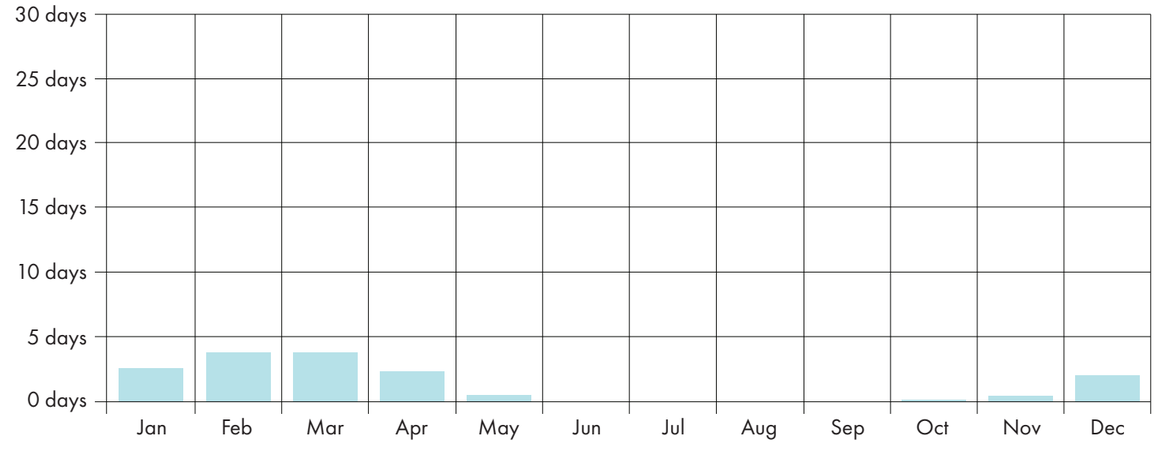
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Solar Energy (kWh)	4.3	5.1	5.9	6.7	7.6	7.9	7.3	6.9	6.6	5.7	4.6	4.0



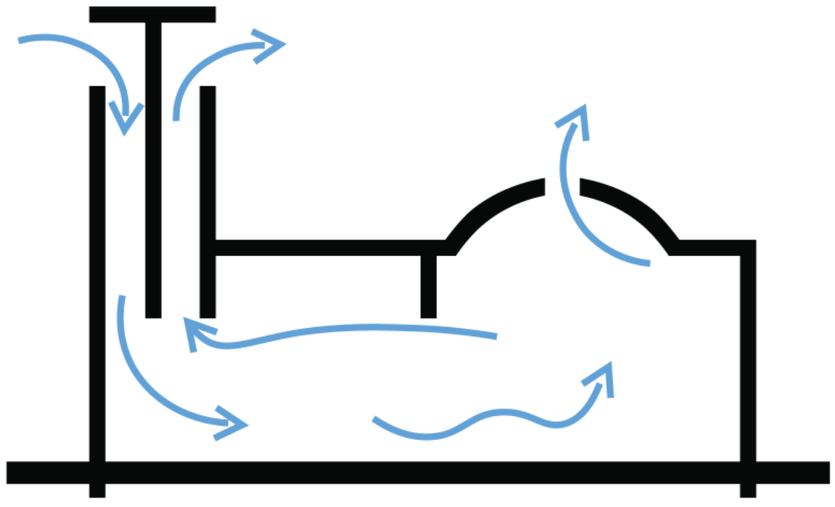


Annual Rainfall Analysis



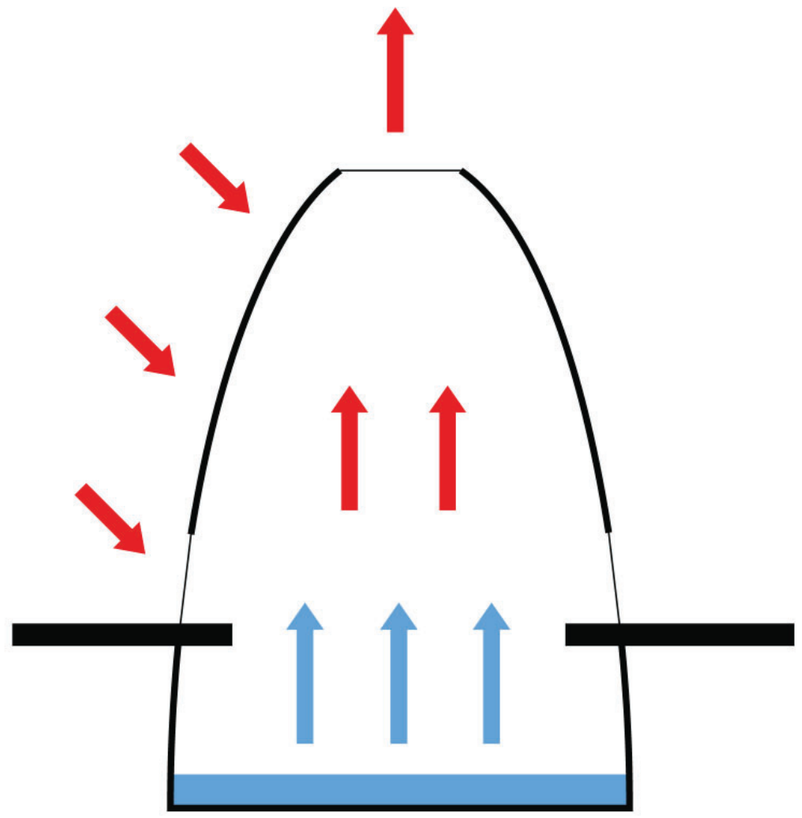


Learning From The Past - Sustainable Energy



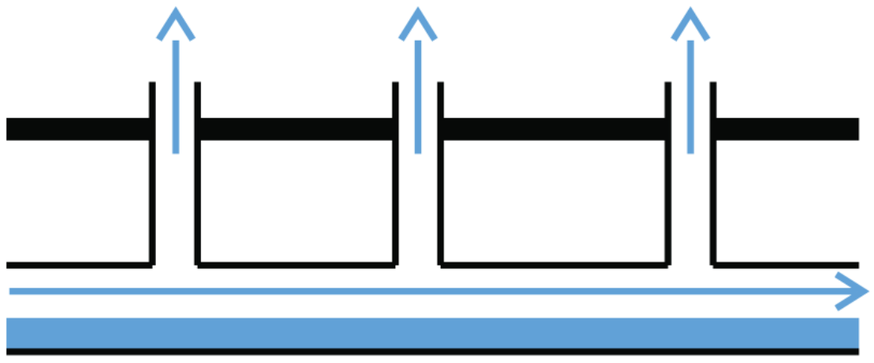
Wind Tower

Yakchal



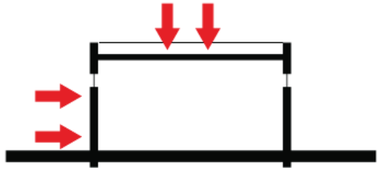
Yakchal

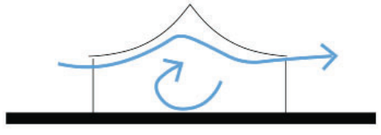
Nebataeans Water Management

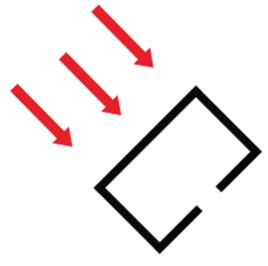


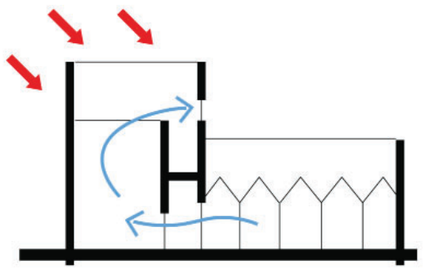
Qanat System

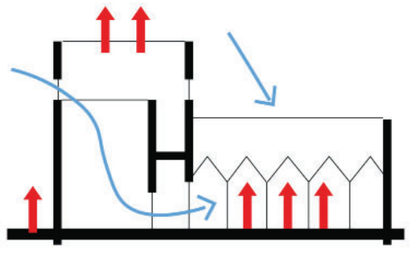
Heat Mitigation and Air Circulation

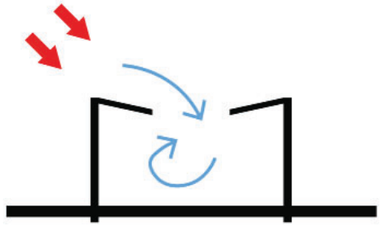








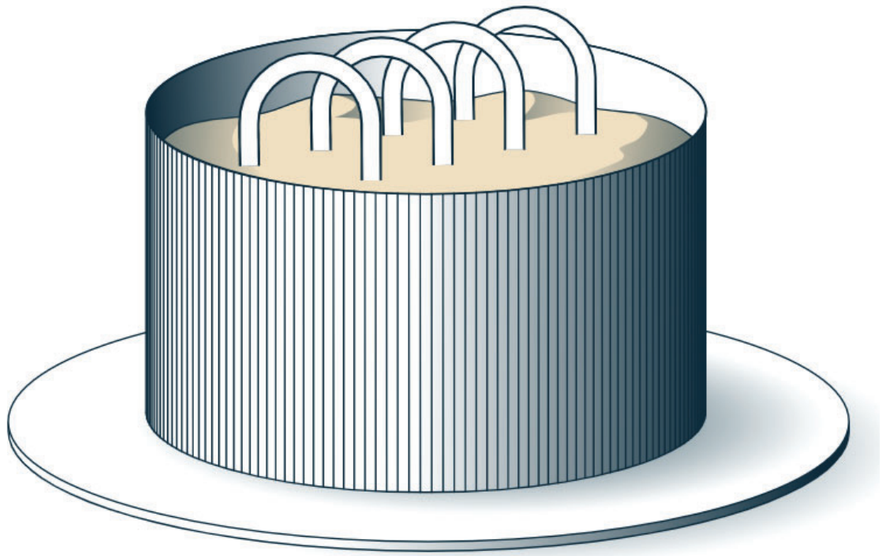




Modern Technologies

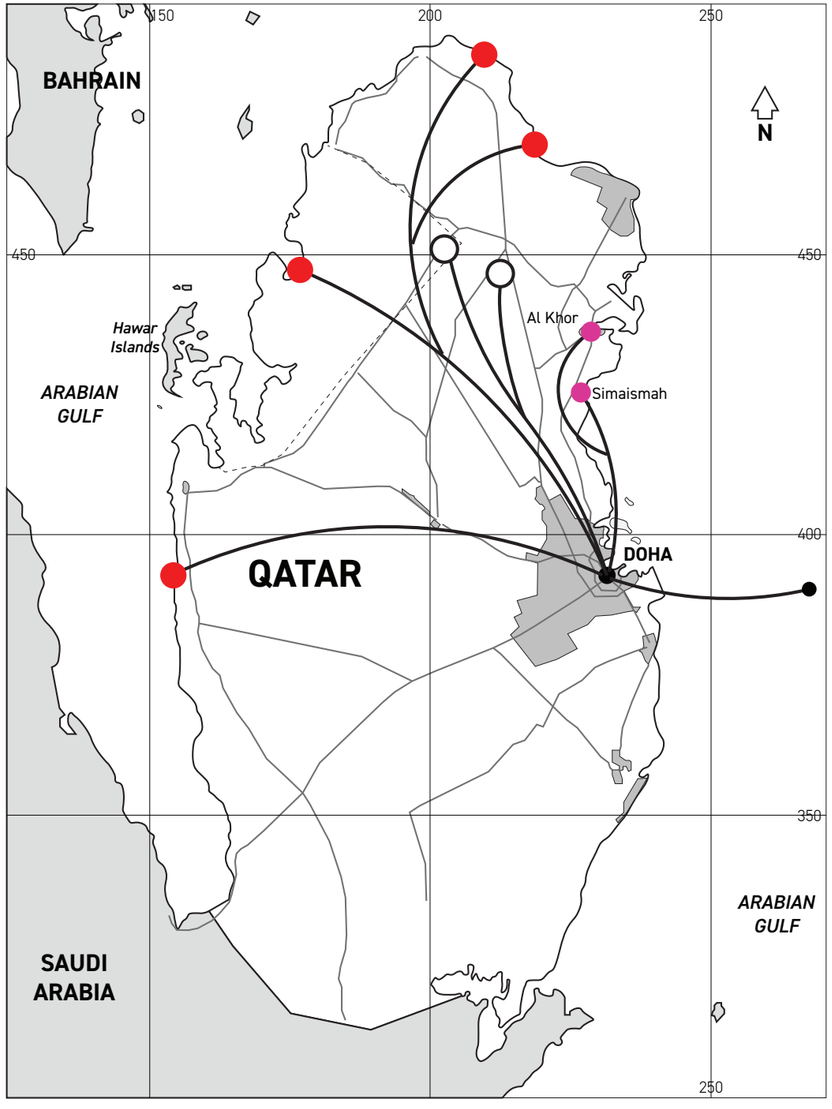
Modern Technologies

Solar Panels, Hydro Panels, Sand Battery



Materials

Materials Extraction Map

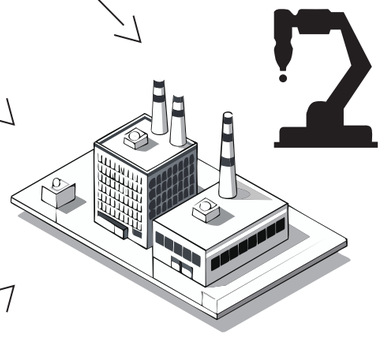


Extraction to Prefabrication

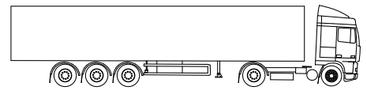
Forest in India

Timber stores CO2

Golden Bamboo grown locally



Prefabricate construction parts
and vertical farm modules in an
industrial plant with CNC modelling
and water jet machines



Transport by truck from factory to site

Local Quarries

Limestone
Sandstone

Clay
Gypsum
Cob (Clay, Water, Earth, Soil, Straw)

User Usage

Target User Groups and Annual Use

Locals

Families

School Groups

Young Adults

The target audience are mainly for locals composed of families with children and social groups among adults

Social Activities

Winter Night Camping

Traditional Cooking Classes

Outdoor Cinema

Wedding Location

Working Spaces

Campfire Music Events

Workshops

Masterplan Strategies

Qatar National Vision 2030

Social Development

"The family is the basis of the society. A Qatari family is founded on religion, ethics, and patriotism. The law shall regulate adequate means to protect the family, support its structure, strengthen its ties, and protect maternity, childhood, and old age."

- Permanent Constitution

Economic Development

The State shall guarantee freedom of economic enterprise on the basis of social justice and balanced cooperation between private and public activity in order to achieve socio-economic development, increase in production, achieve public welfare, raise standard of living, and provide job opportunities in accordance with the provision of the law."

Permanent Constitution

Environmental Development

The State shall preserve the environment and its natural balance in order to achieve comprehensive and sustainable development for all generations."

- Permanent Constitution

" We need to care for our natural environment for it was entrusted to us by God to use with responsibility and respect for the benefit of human kind. If we nurture our environment, it will nurture us."

- Mozah bint Nasser Al-Misnid, mother of the current Emir

Human Development

Social Development

Economic Development

Environmental Development

Site Focus

Vacant Locations

Thesis Location

N

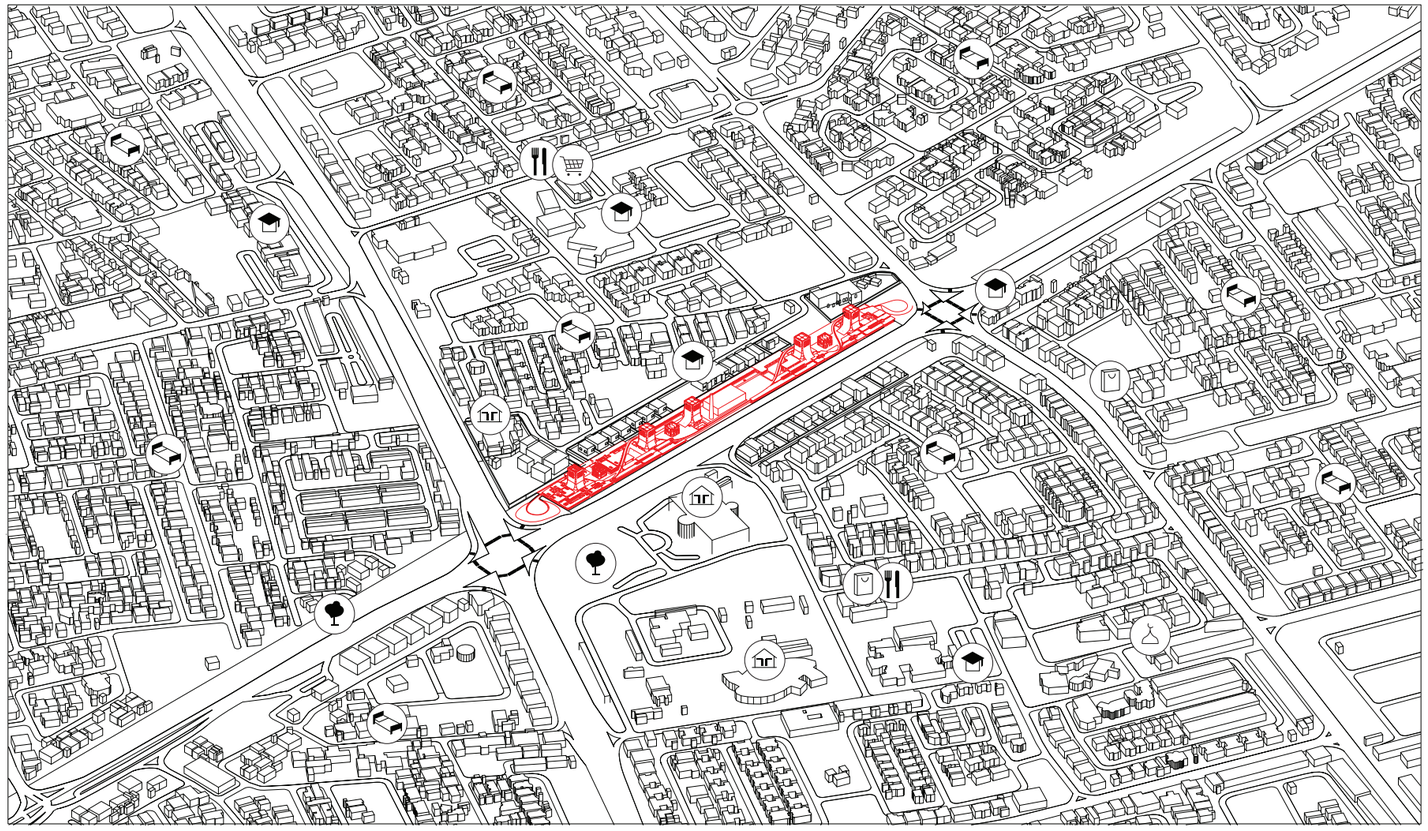
2000m

5000m

Site Access

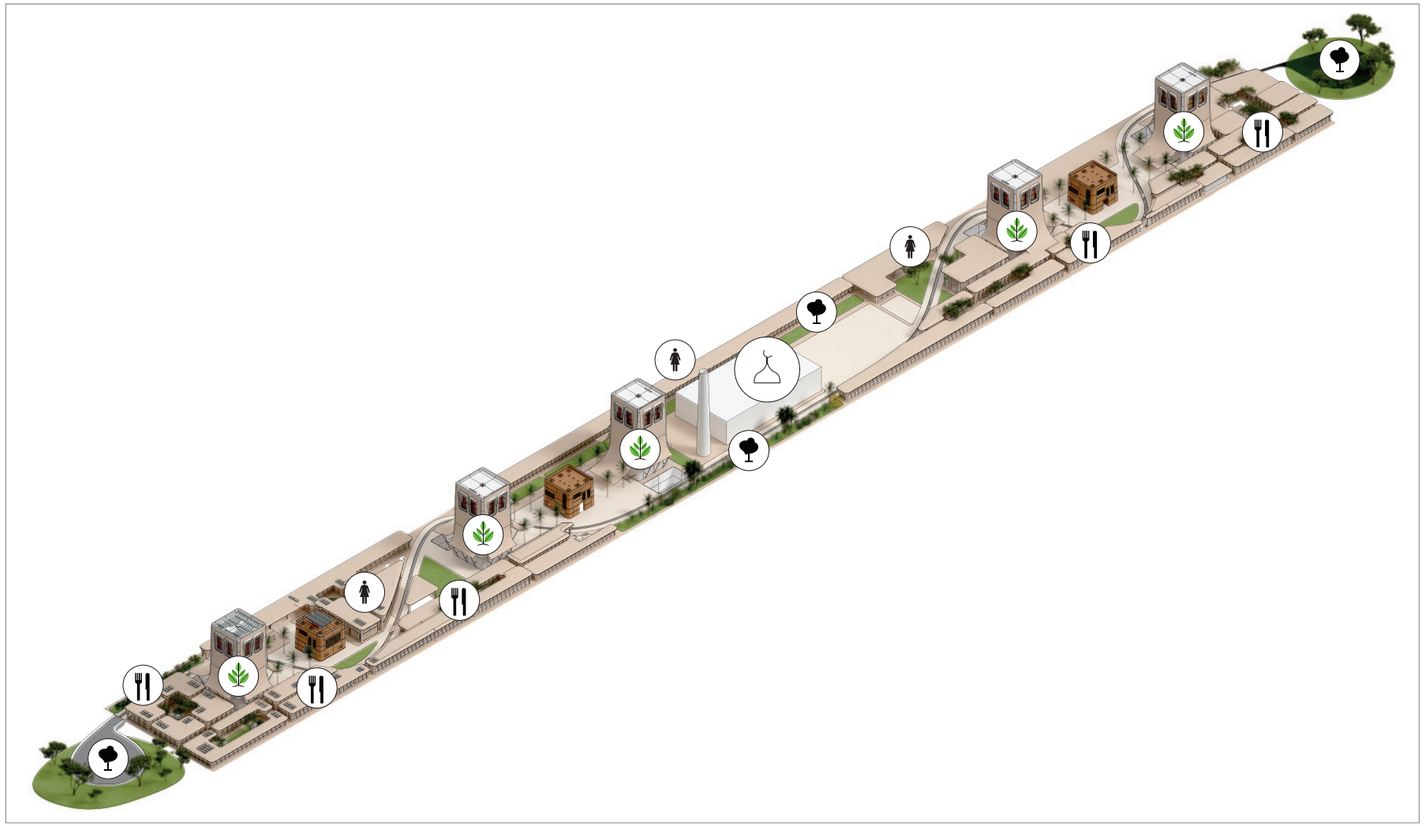

Doha Old Town
Hamad International Airport
Al Thumama Stadium
Residential
Residential
Residential
Residential
N
500m

Existing Site Usage



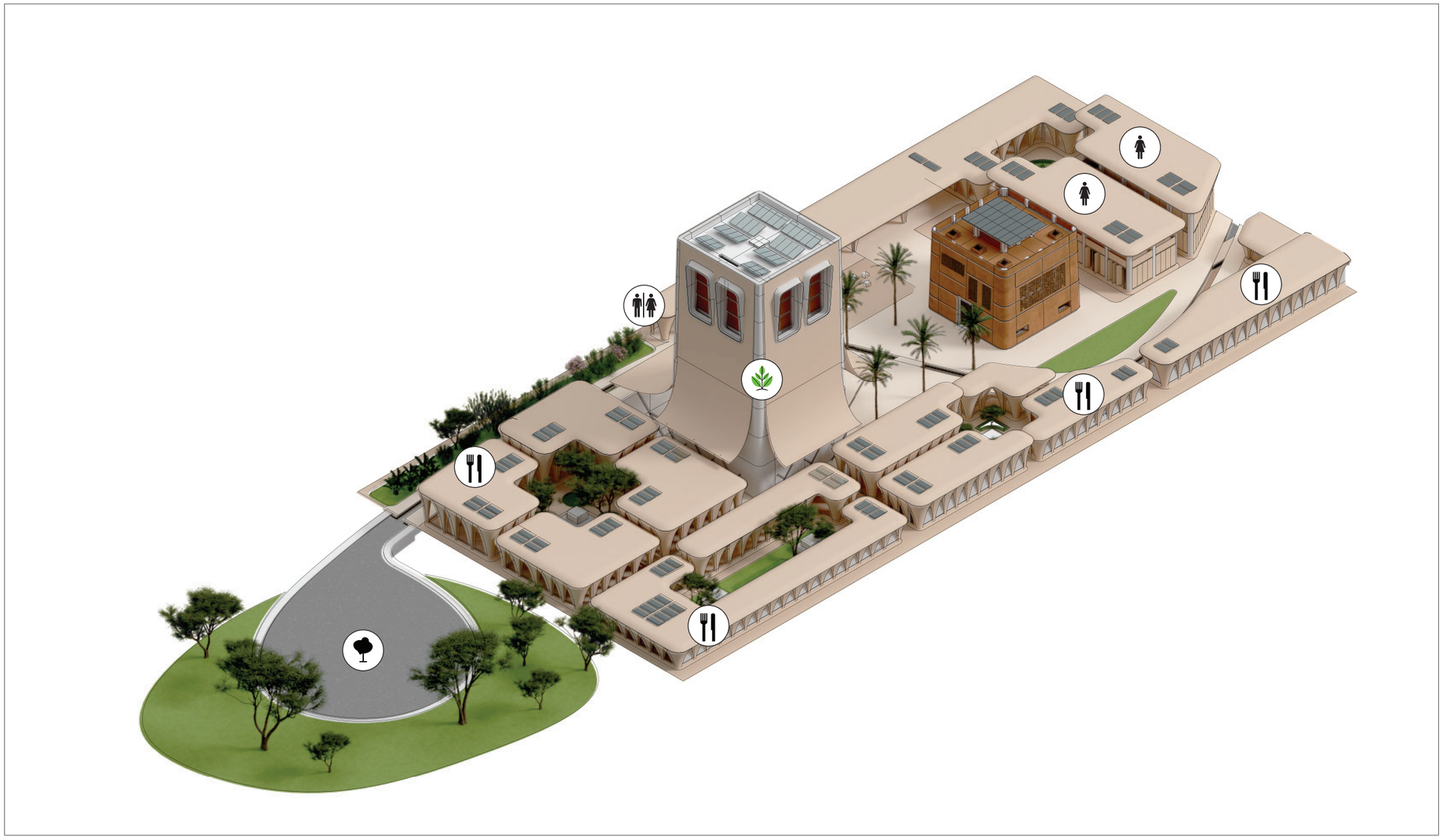
Homes Shop Government Food Park School Grocery Mosque

Site Activation in a Dominant Housing Location



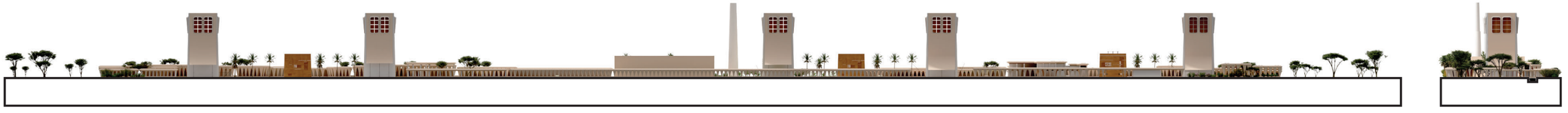
Vertical Farm Food Park Mosque Women Only Space

Site Activation in a Dominant Housing Location



Vertical Farm Food Park Mosque Toilet Women Only Space

Masterplan Elevations



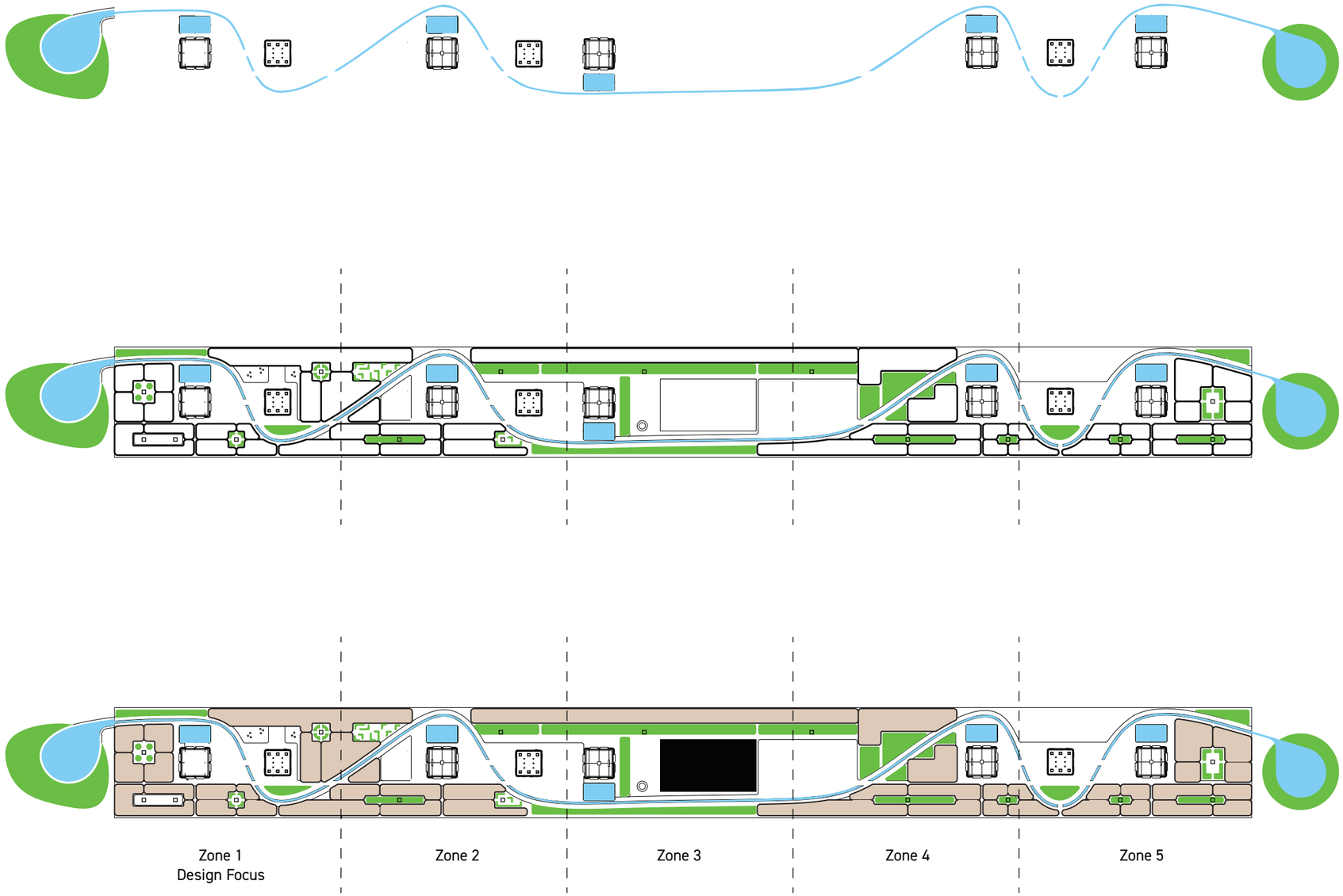
Al Hijla Street Elevation

551.5 m

53.4 m

Al Thumama Elevation

Masterplan Urban Ecology Strategies



Urban Ecology - Desert Climate Vegetation

Courtyard Gardens

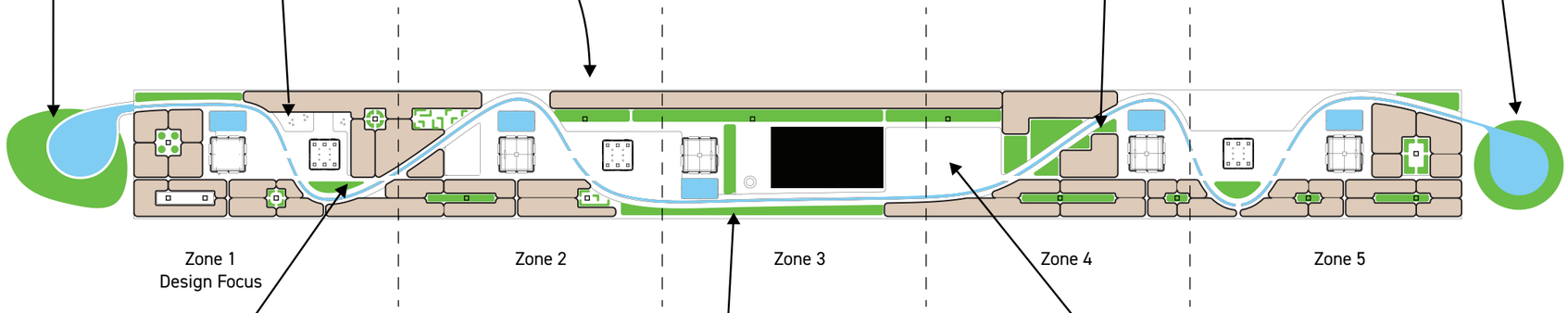
4. Rawda Depressions

5. Water Garden

6. Desert Flowers

5. Water Garden

4. Rawda Depressions



Courtyard Gardens

1. Vegetation along Wadis

2. Inland Grasslands

3. Shallow Depressions

7. Quranic Flora

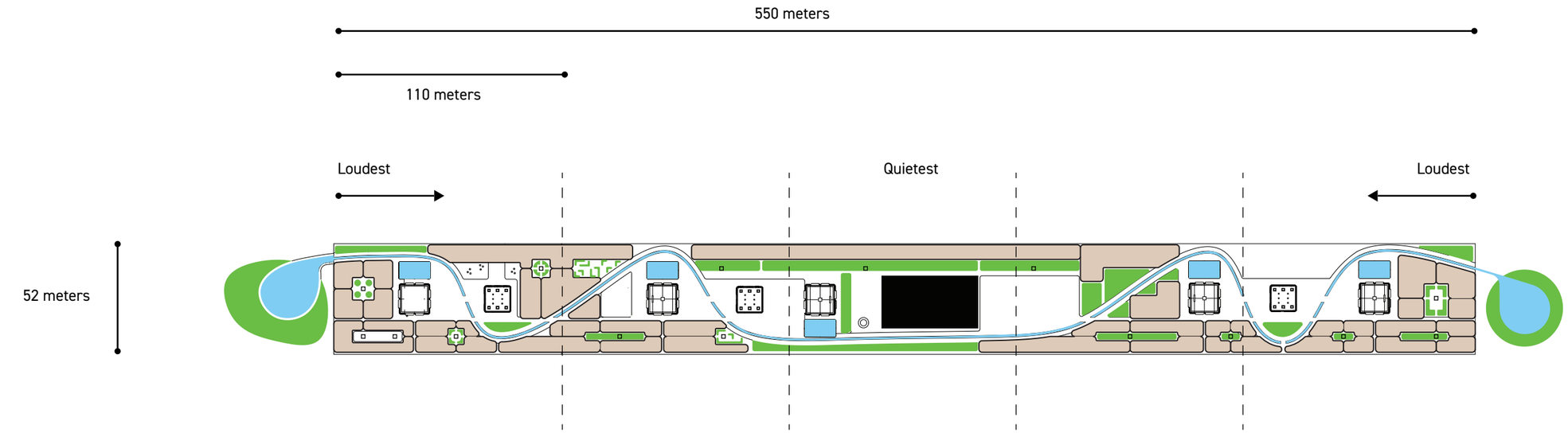
8. Medicinal Plants

10. Firewood and/or Charcoal

11. Animal Food

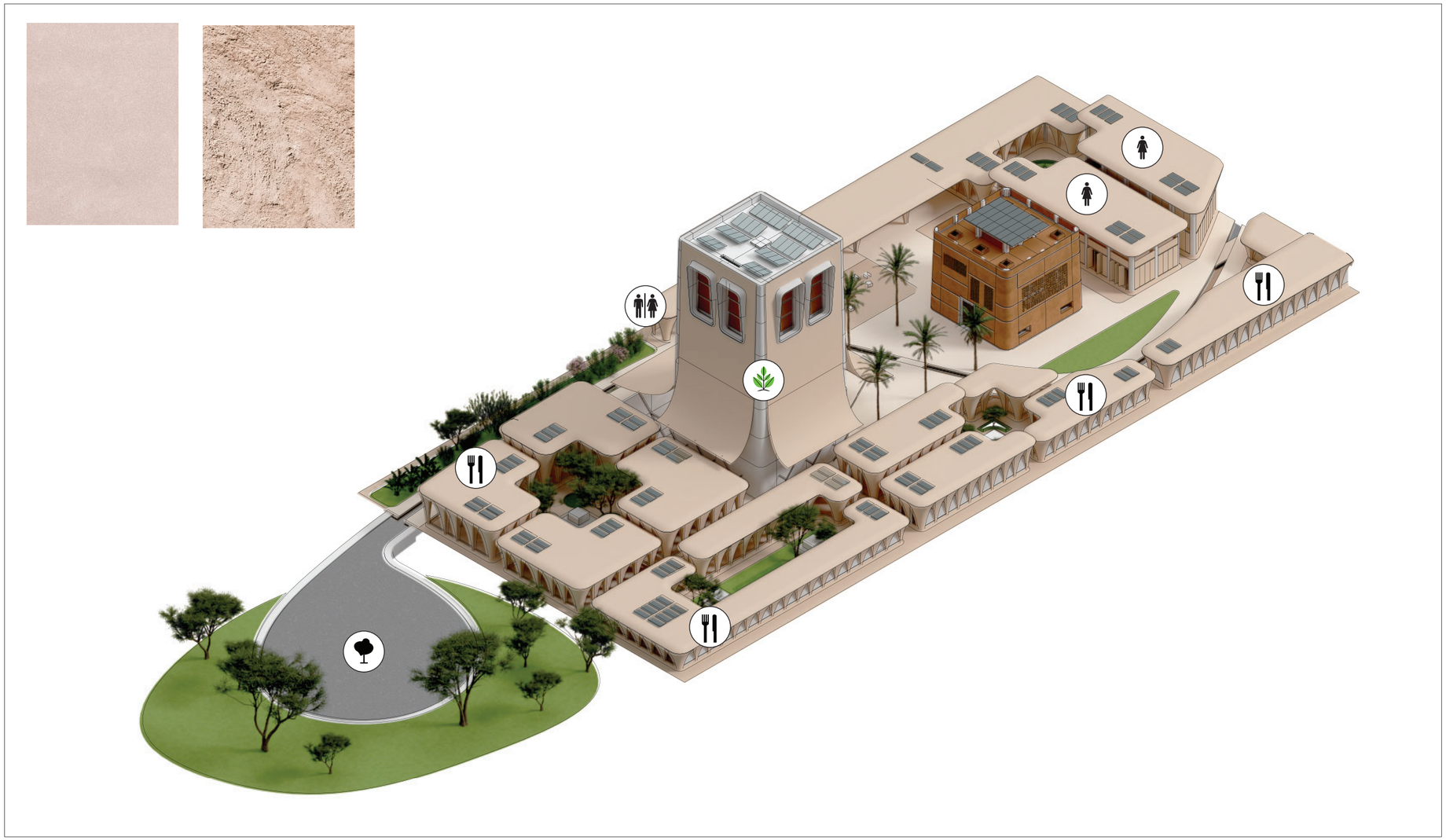
Grown on Kitchen rooftop

Masterplan Zoning & Noise Levels



Zone 1 - Design Focus

Site Activation in a Dominant Housing Location



Vertical Farm Food Park Mosque Toilet Women Only Space

Elevations

Al Hijla Street Elevation

Elevations

Al Hadara Street Elevation

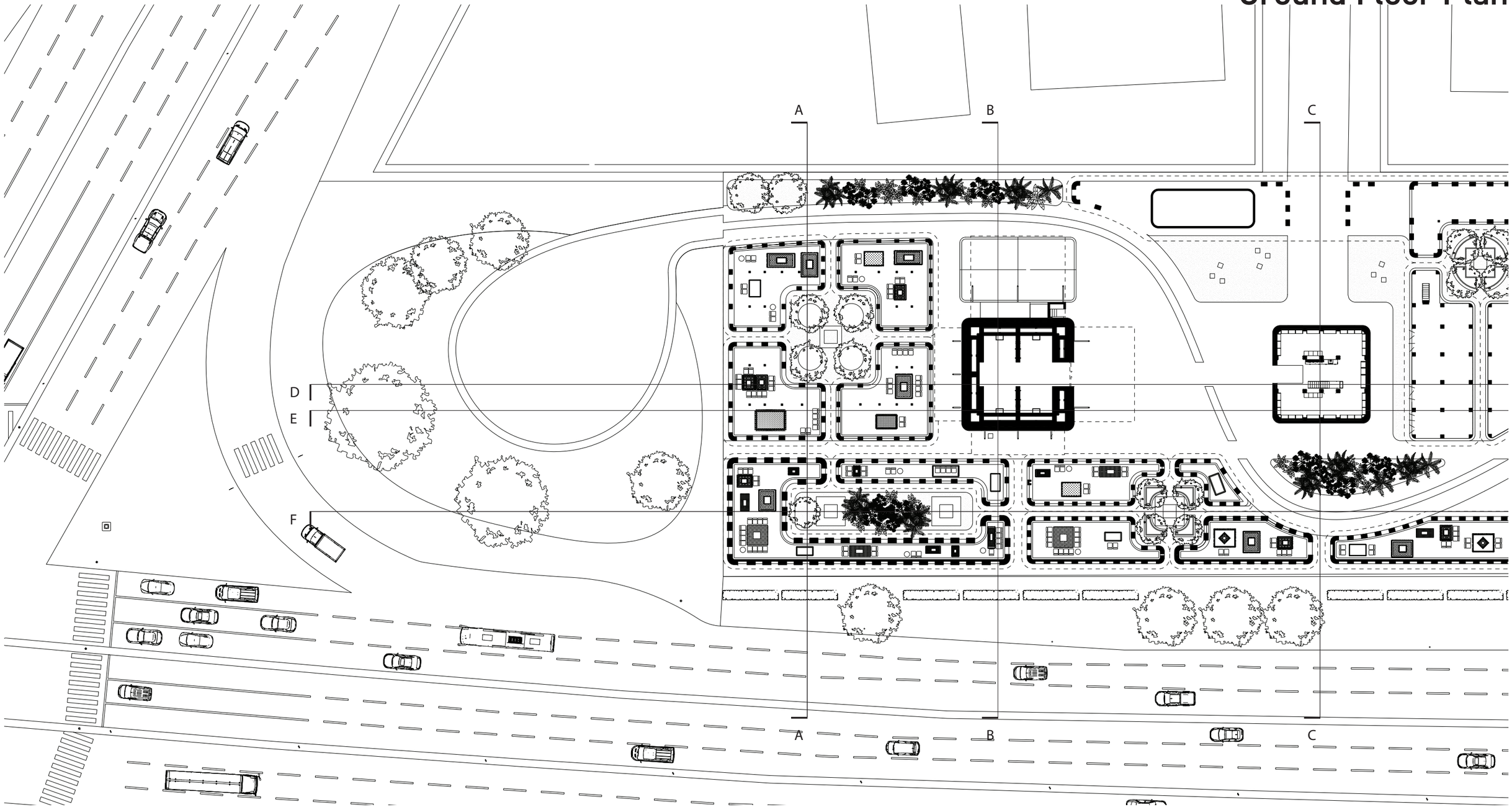
Elevations

Al Thumama Elevation

Elevations

Najma E Ring Road Elevation

Ground Floor Plan

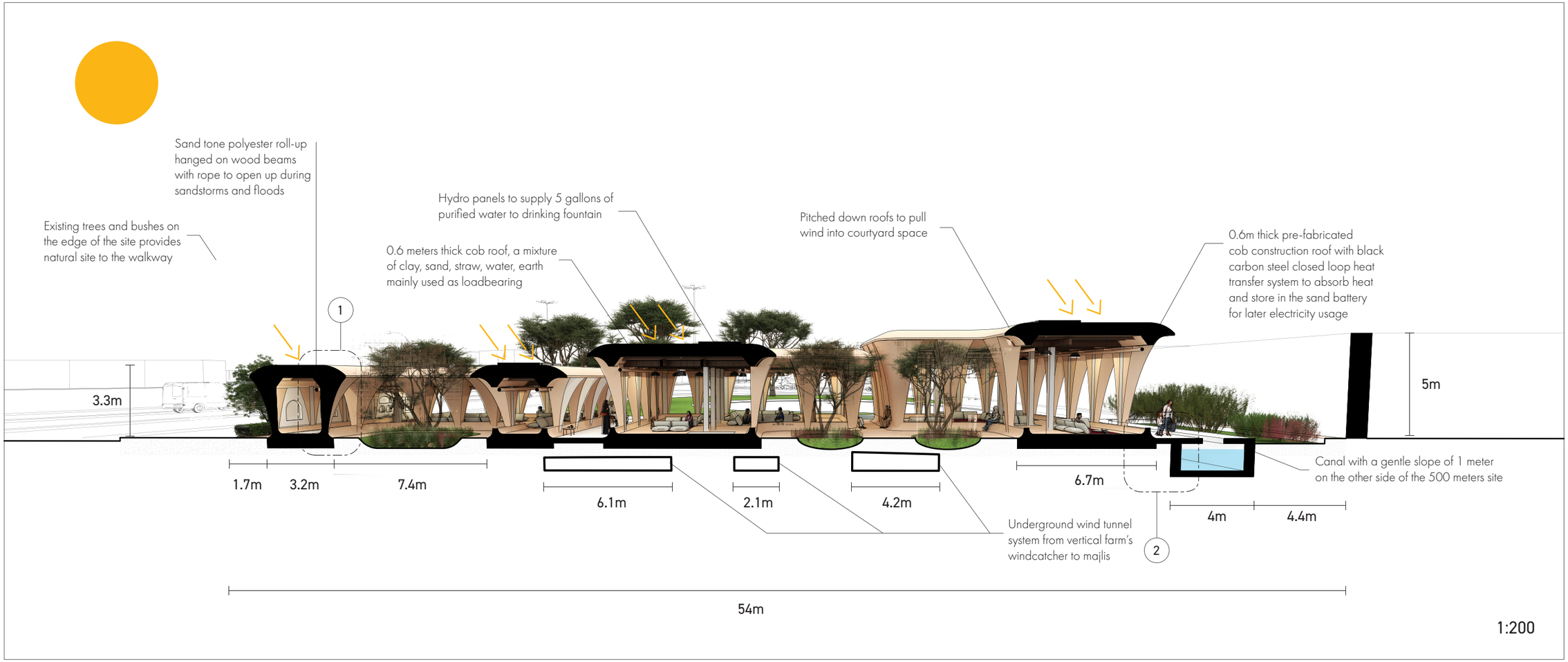


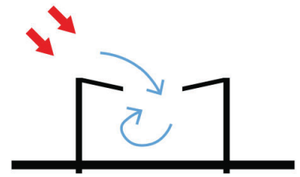
Approaching Al Hijla Vertical Farm

Public Street - Main Entrance 1

Wadi - Main Entrance 2

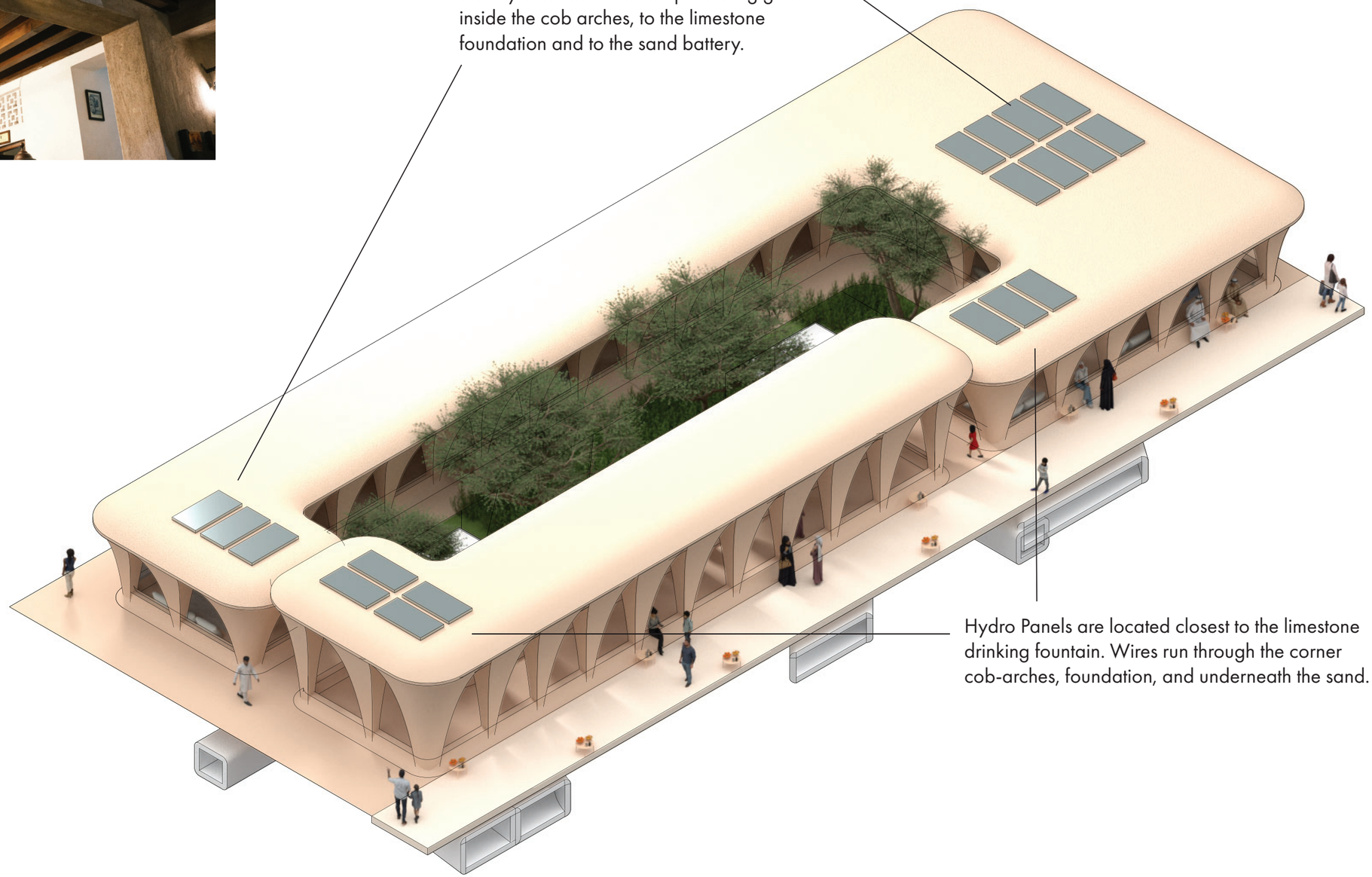
Cross Section A





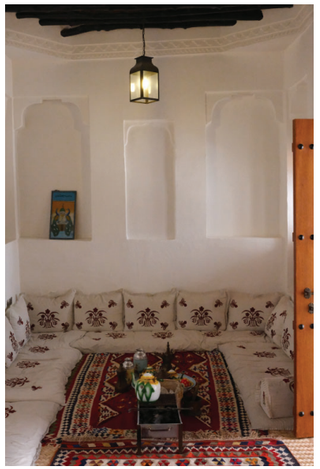
Majlis

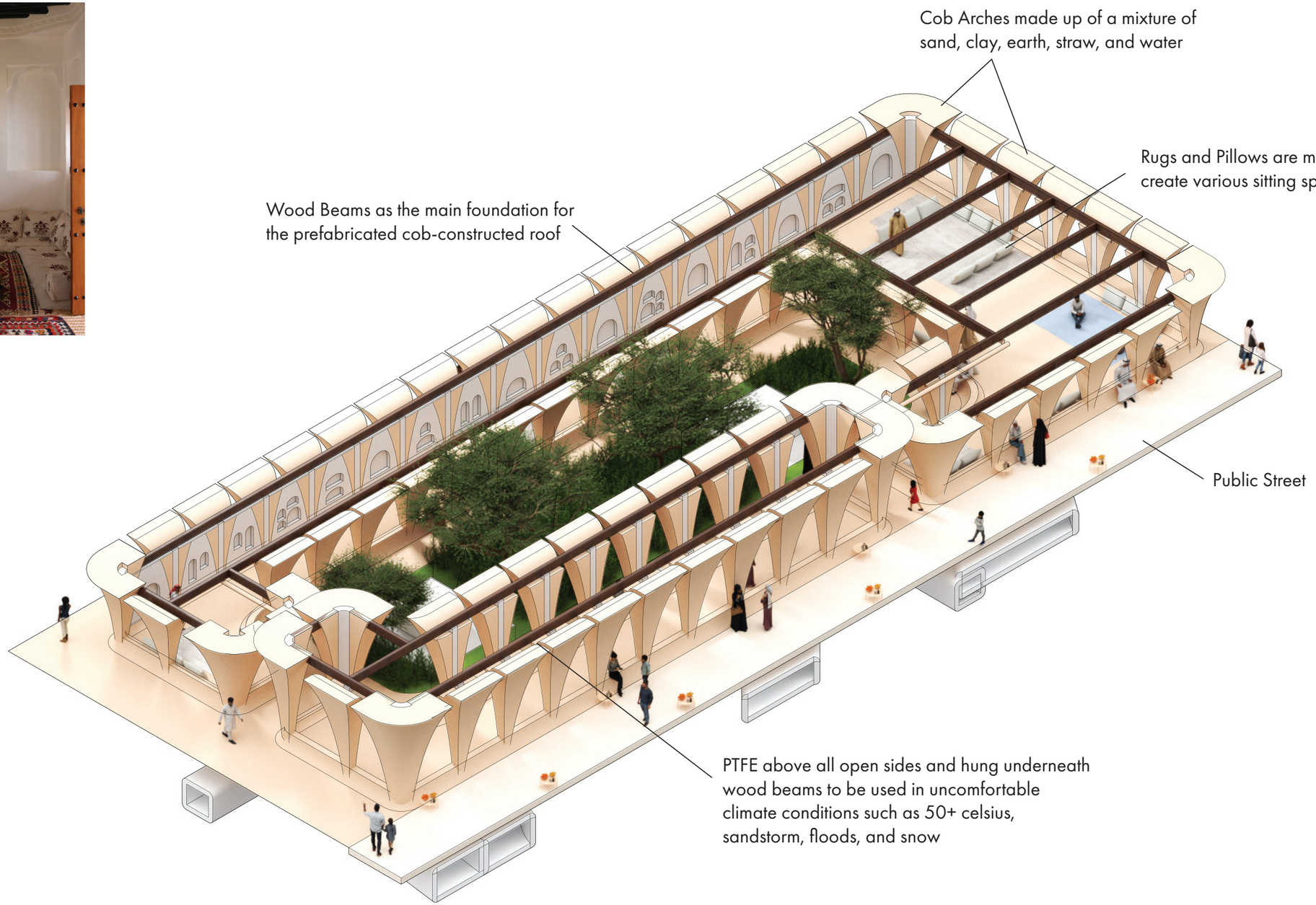
Solar panels to provide electricity for daily use. Excess production goes directly to the sand battery underneath the majlis. Tubing goes inside the cob arches, to the limestone foundation and to the sand battery.



Hydro Panels are located closest to the limestone drinking fountain. Wires run through the corner cob-arches, foundation, and underneath the sand.

Majlis



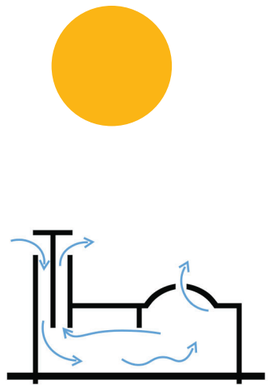

Cob Arches made up of a mixture of sand, clay, earth, straw, and water
Rugs and Pillows are movable to create various sitting spaces sizes
Wood Beams as the main foundation for the prefabricated cob-constructed roof
Public Street
PTFE above all open sides and hung underneath wood beams to be used in uncomfortable climate conditions such as 50+ celsius, sandstorm, floods, and snow

Majlis

Majlis

Zone 1 - Design Focus

Cross Section B



Solar and Hydro panels on the roof to supply electricity and purified water for the aquaponics system

Limestone parapet

3

Windcatcher on each side of the vertical farm to channel wind downwards and into the underground tunnel system

0.5m

7.1m

Sand tone polyester to prevent sunlight glare and provide shade

0.5 meters wide cavity align with clay walls on each side to cool down outside hot air. Constricted tunnel also known as a "venturi effect" increases wind velocity up to 4 times

Pitched down roofs to pull wind and cool spaces below

Excess water in underground storage air pumps into fish tank

Existing wall

24.7m

37.1m

5m

1.2m

0.6m

1.6m

5.5m

7.1m

Canal

Fish tank

Qanat system to supply excess water to the man-made lake. Runs underneath AC tunnel system to further cool air to majlis.

Underground wind tunnel to supply 15 degrees Celsius cooler air to majlis

4

5.2m | 1.3m | 9.9m | 14.9m | 2m | 8.6m | 4m | 4m

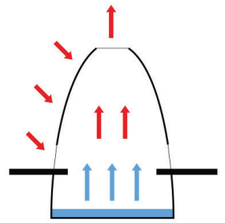
54m

1:200

Majlis

Plaza

Cross Section C



Yakchal

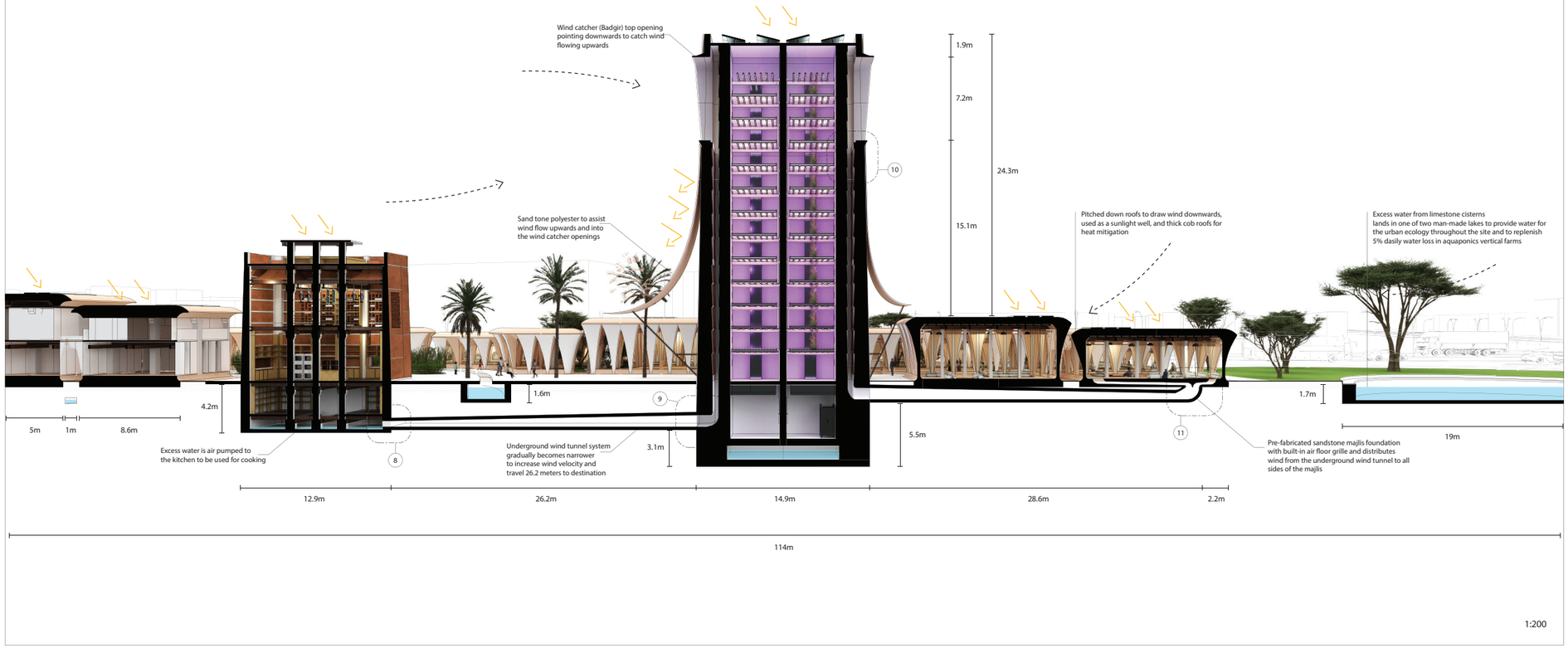
1:200

Kitchen

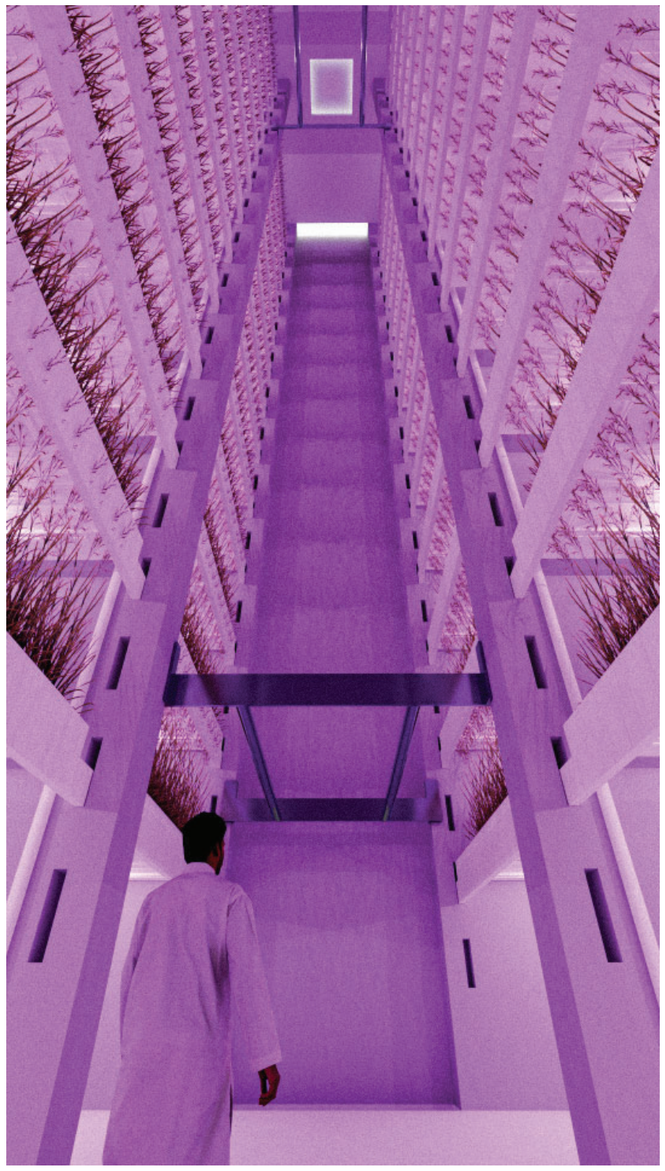
Longitudinal Section D

1:200

Longitudinal Section E

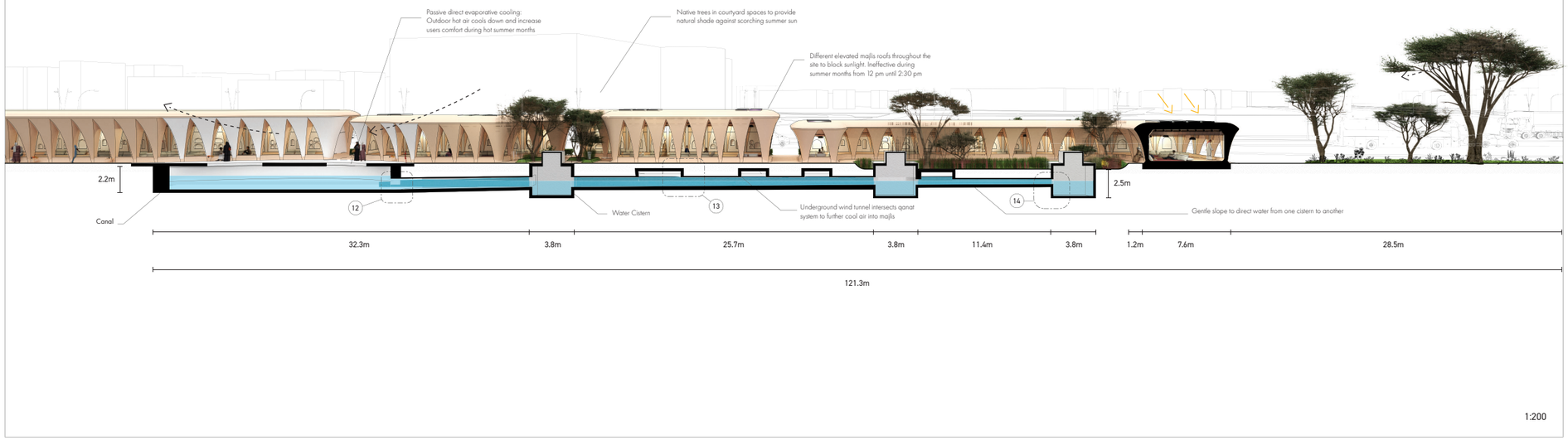


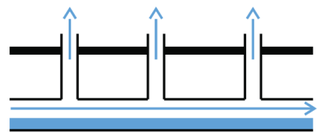
Inside Al Hijla Vertical Farm



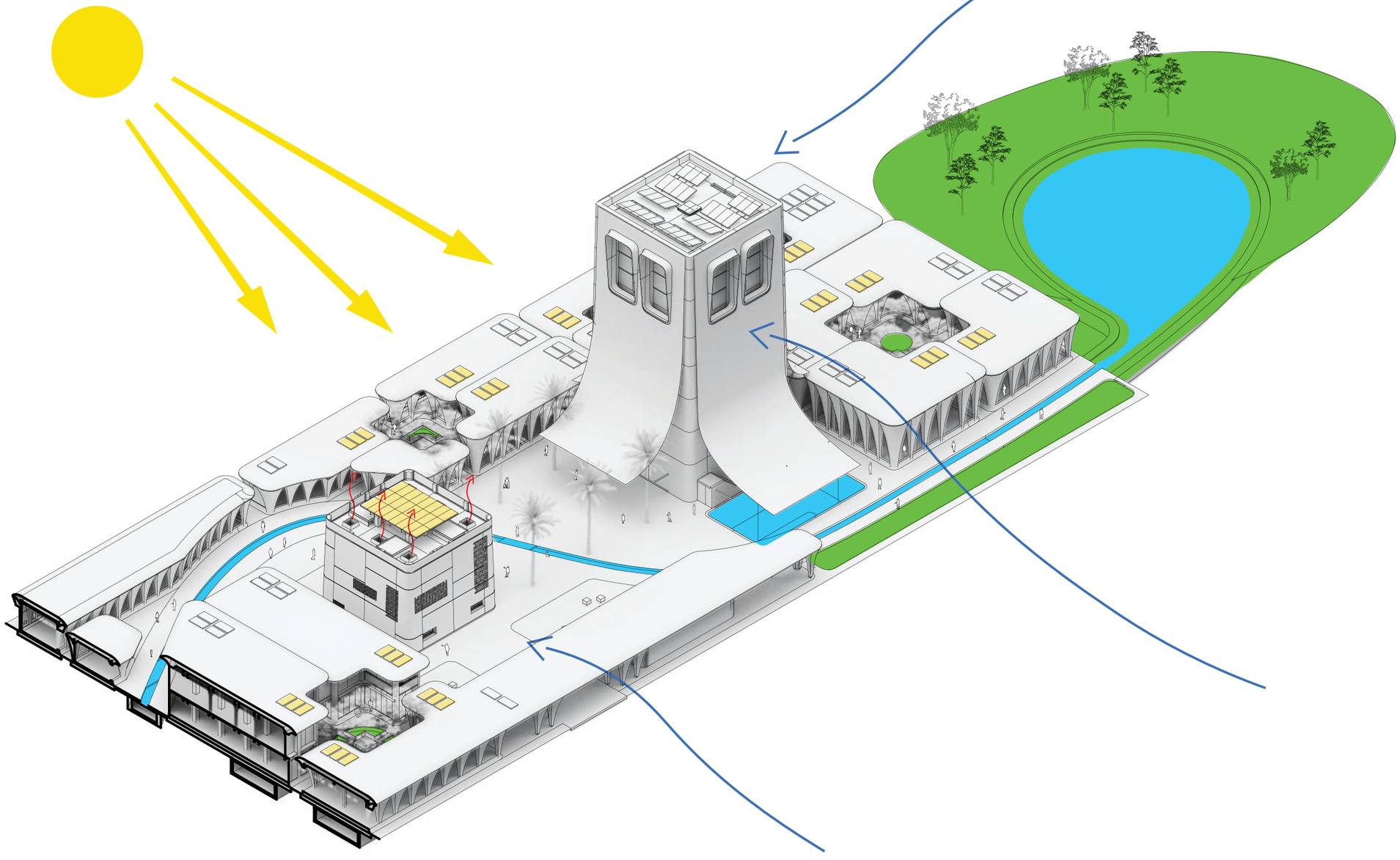
Majlis Courtyard

Longitudinal Section F

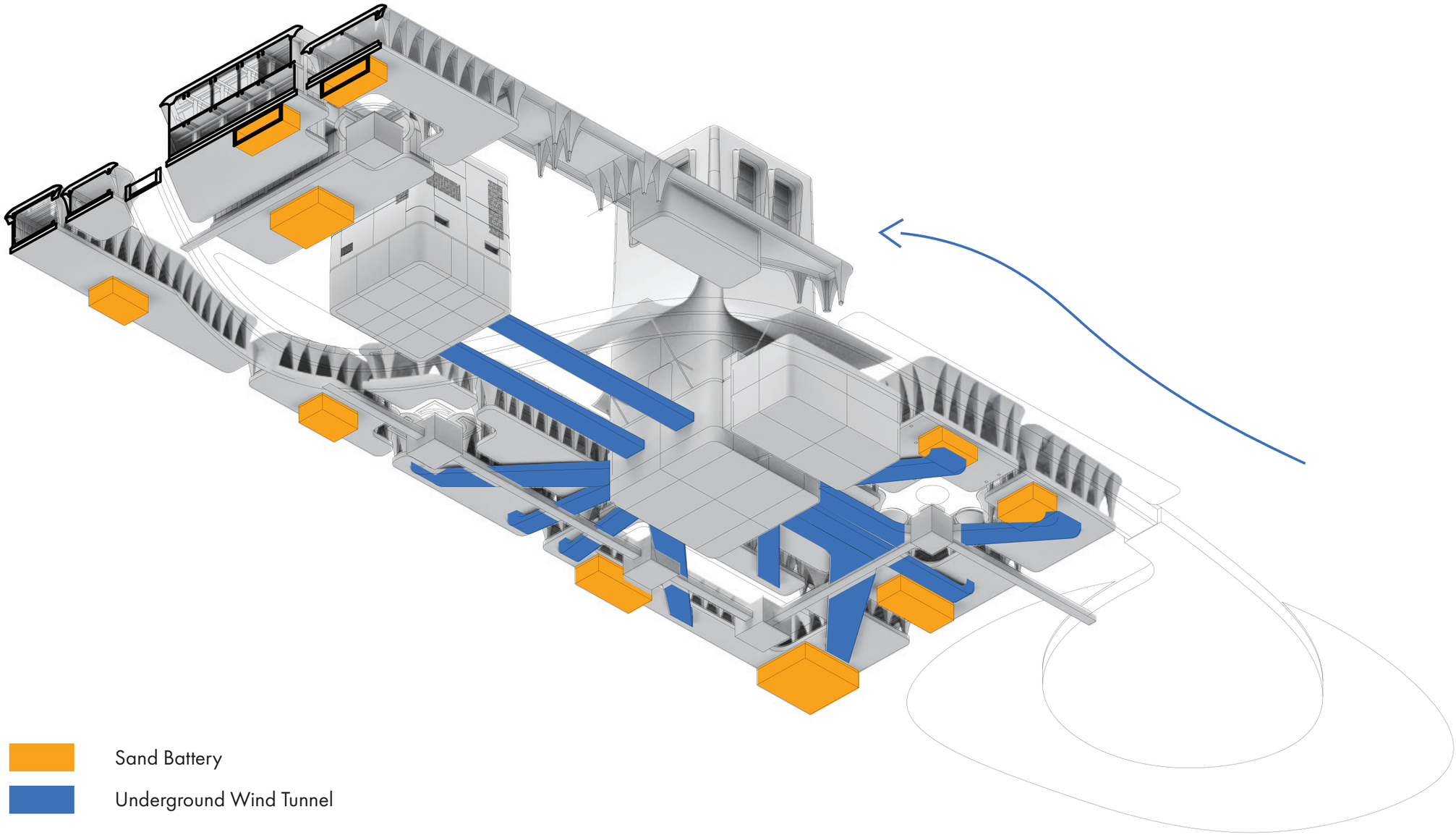




Building Engineering Technology Isometric Overview



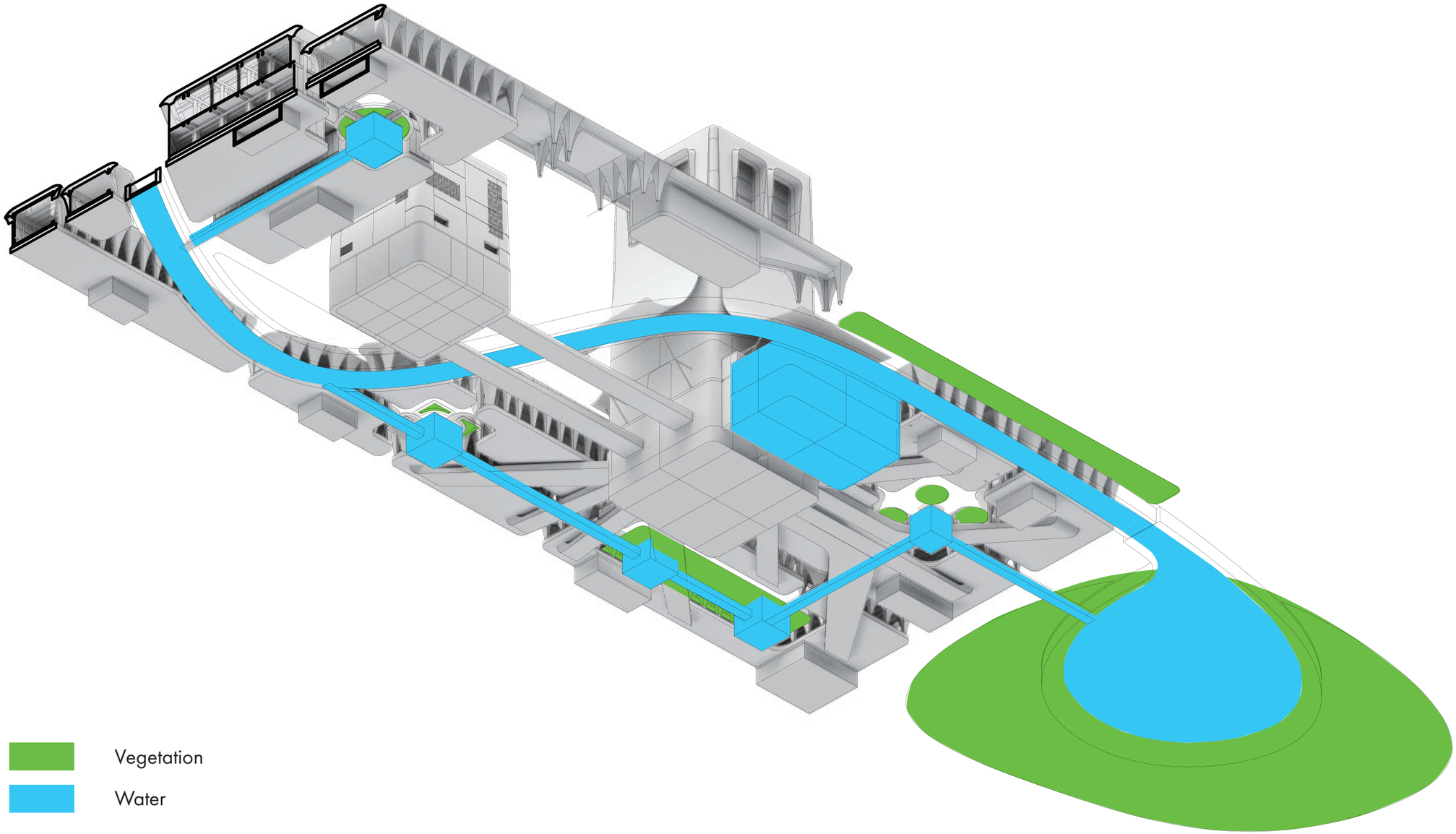
Building Engineering Technology Worm's Eye



Sand Battery

Underground Wind Tunnel

Building Engineering Technology Worm's Eye

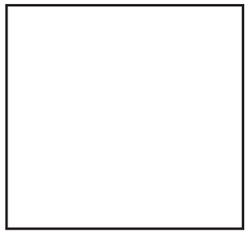


Vegetation

Water

Construction and Engineering Design Proposal

Bustanica Vertical Farm, Dubai, Parameters

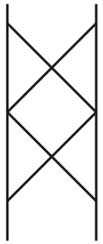


Concrete Walls
x200

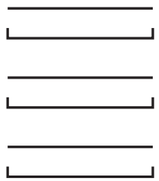
Concrete Columns
x50

Floor Plates
x200

Catwalk Stairs
x30

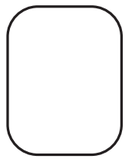


Grow Towers
x27



Grow Stacks
x1000

Fish Tank
x6



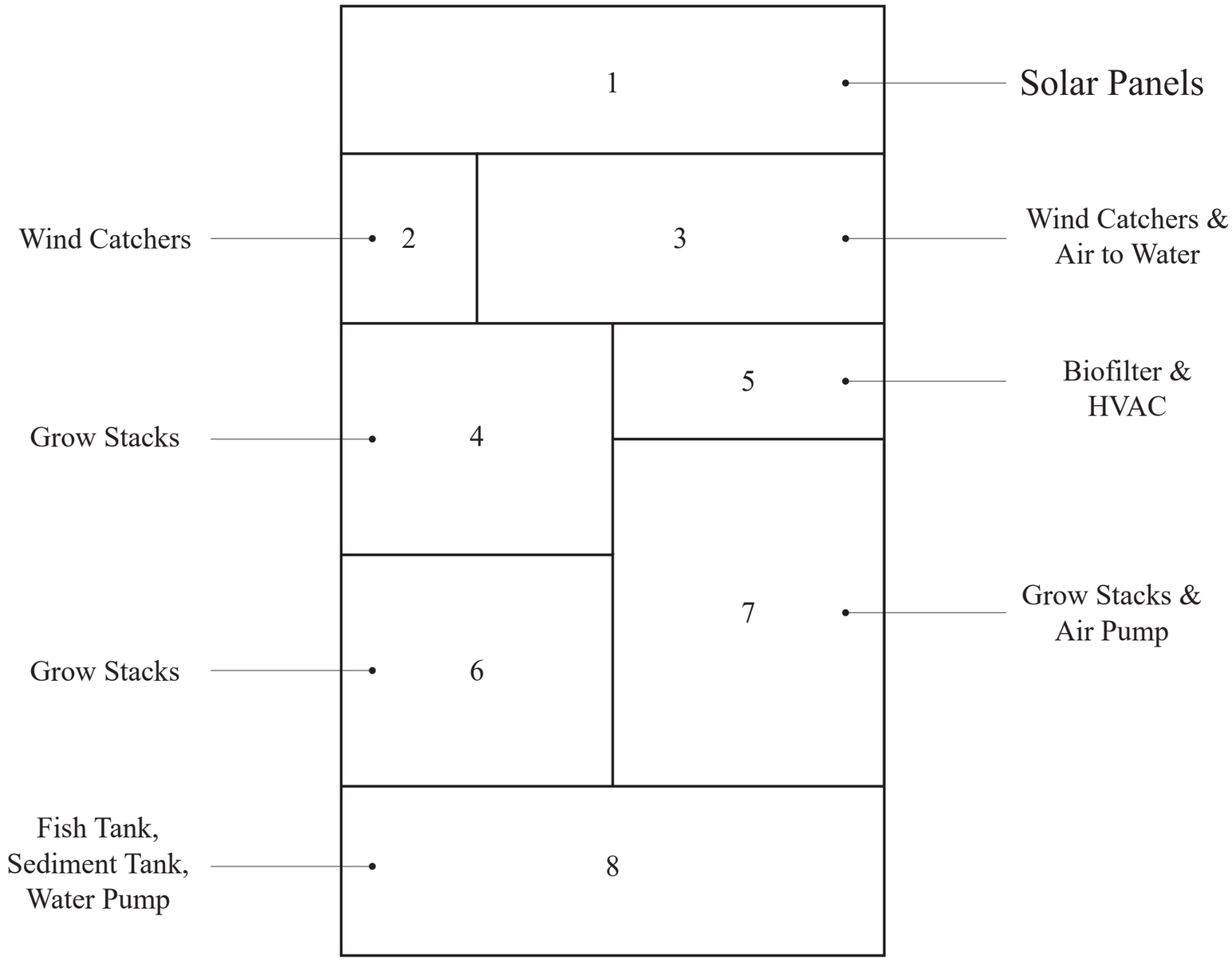
Biofilter
x6

A.I. Assisted Facility components

Parameters	**Outcome**
Food	Lettuce, Berries, Parsley, Kale,
Farm Type	Hydroponics
Total Floor Area	31,000 sqm
Daily Yields	3,000 kilograms
Annual Yields	1,100,000 kilograms
Electricity	573 J per sqm per hour
Water	62,620,000 L (2,020 L per 1000sqm) *95% less water than traditional farm
Grow Stacks	27
Vertical Stacks	3
Vertical Stack Height	6 meters
Labor	In-house team: agronomy experts, engineers, horticulturists, and plant scientists.
Investment	USD 40 million
Technology	Artificial Intelligence

Formula: Every 1,000 sqm floor area of crops requires 573,000 Joules of electricity. One solar panel in Qatar produce 5kWh or 1,800,000 Joules on average throughout the year which could power 3,000 sqm of crops. A 1,000 sqm crop will require 2,020 L of water, 95% of which can be recycled. 1,000 sqm of crops would produce approximately 100 kilograms of food a day.

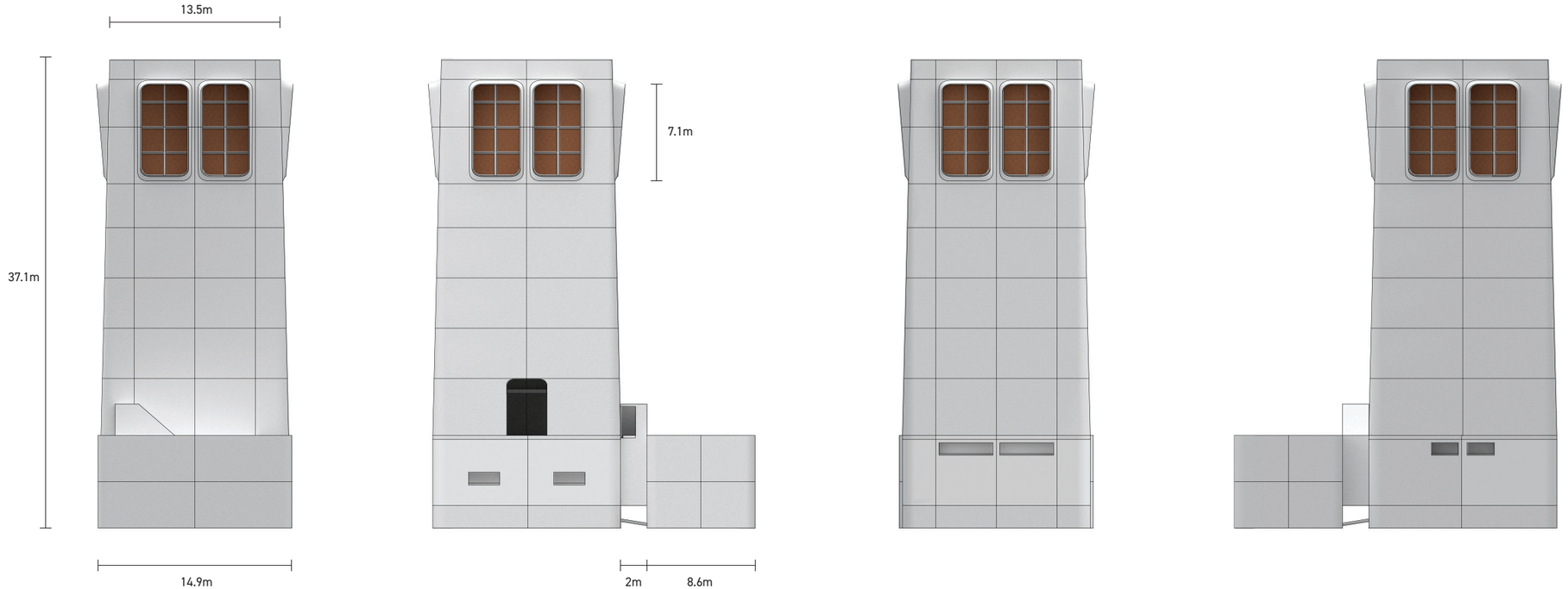
Prefabricated Modular Parts Proposal



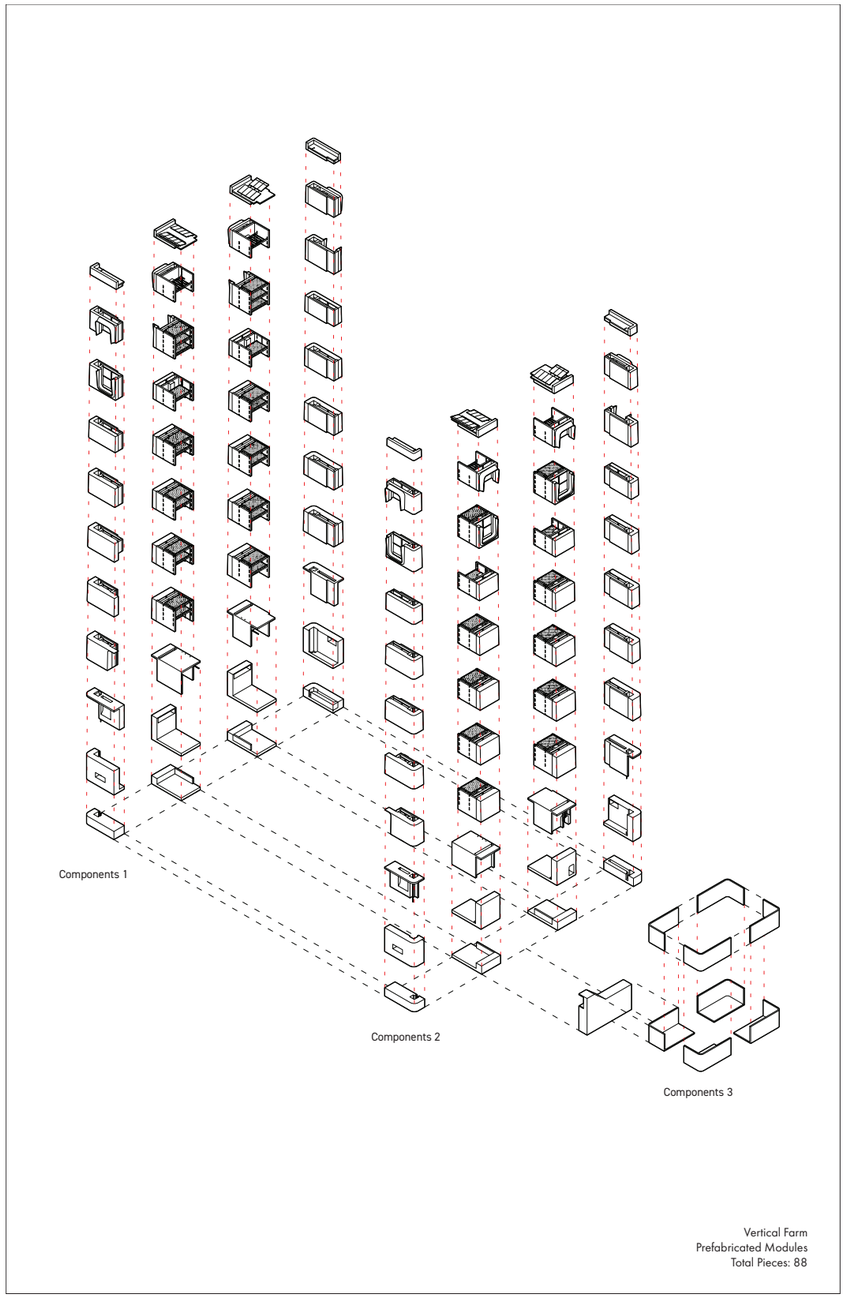
Construction and Engineering Design Proposal

Aquaponics Vertical Farm Instruction Manual

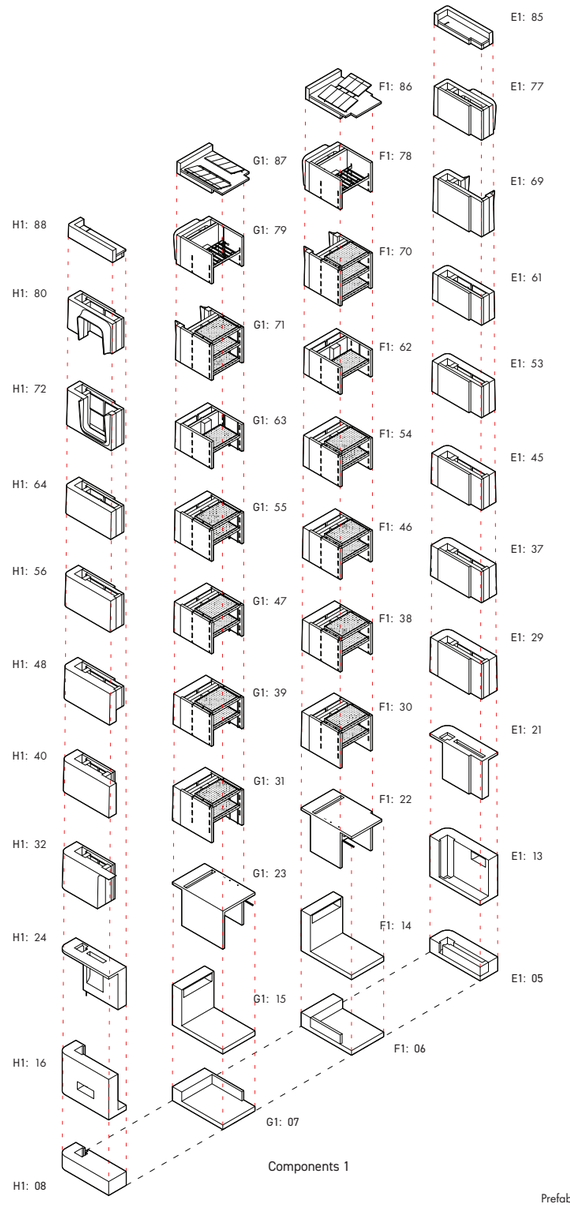
Aquaponics Vertical Farm Instruction Manual



Aquaponics Vertical Farm Instruction Manual

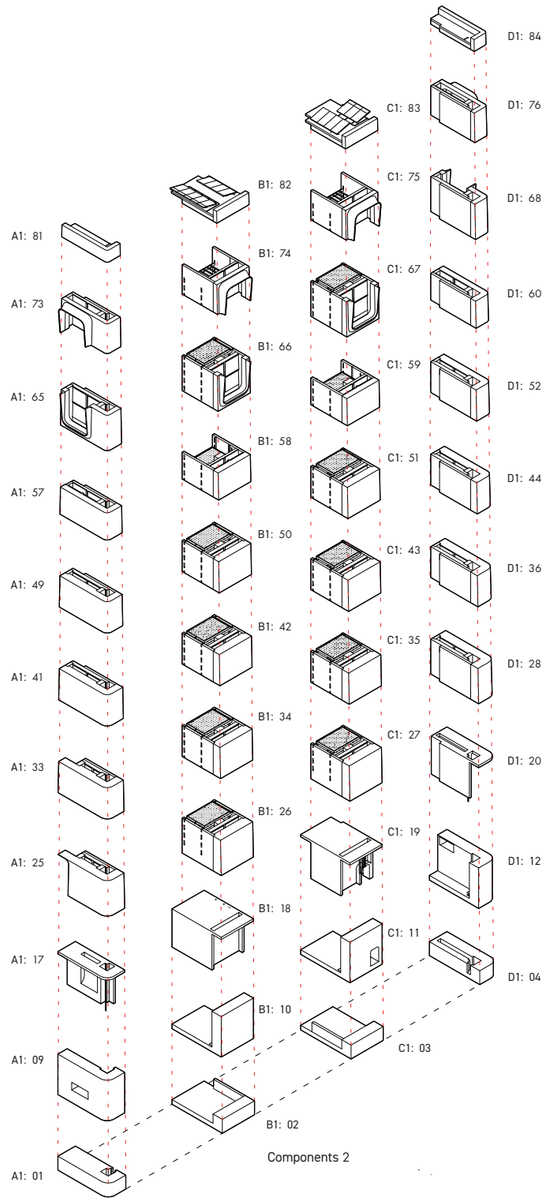


Vertical Farm
Prefabricated Modules
Total Pieces: 88



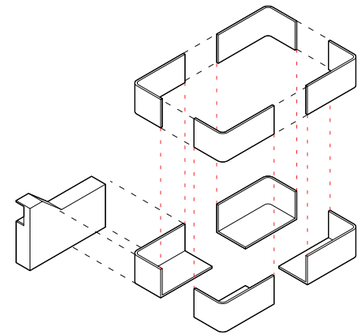
Vertical Farm
Prefabricated Modules
Total Pieces: 88

Aquaponics Vertical Farm Instruction Manual



Components 2

Vertical Farm
Prefabricated Modules
Total Pieces: 88

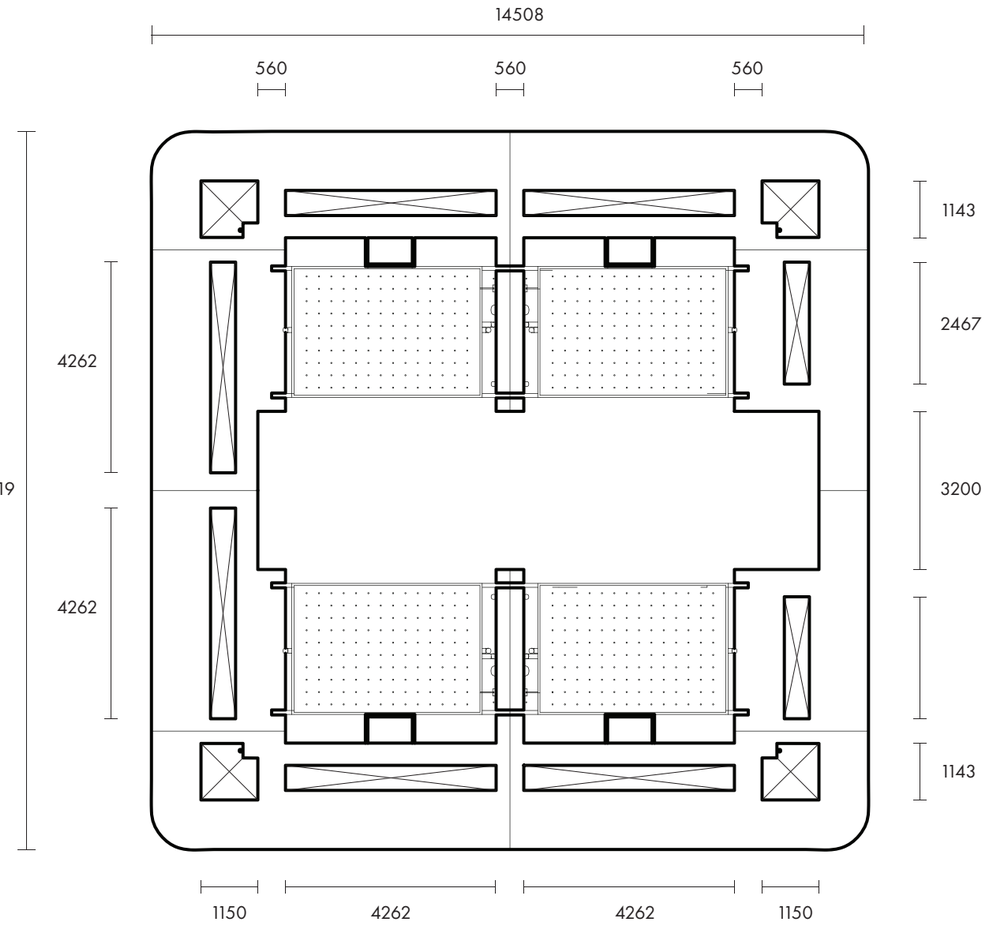


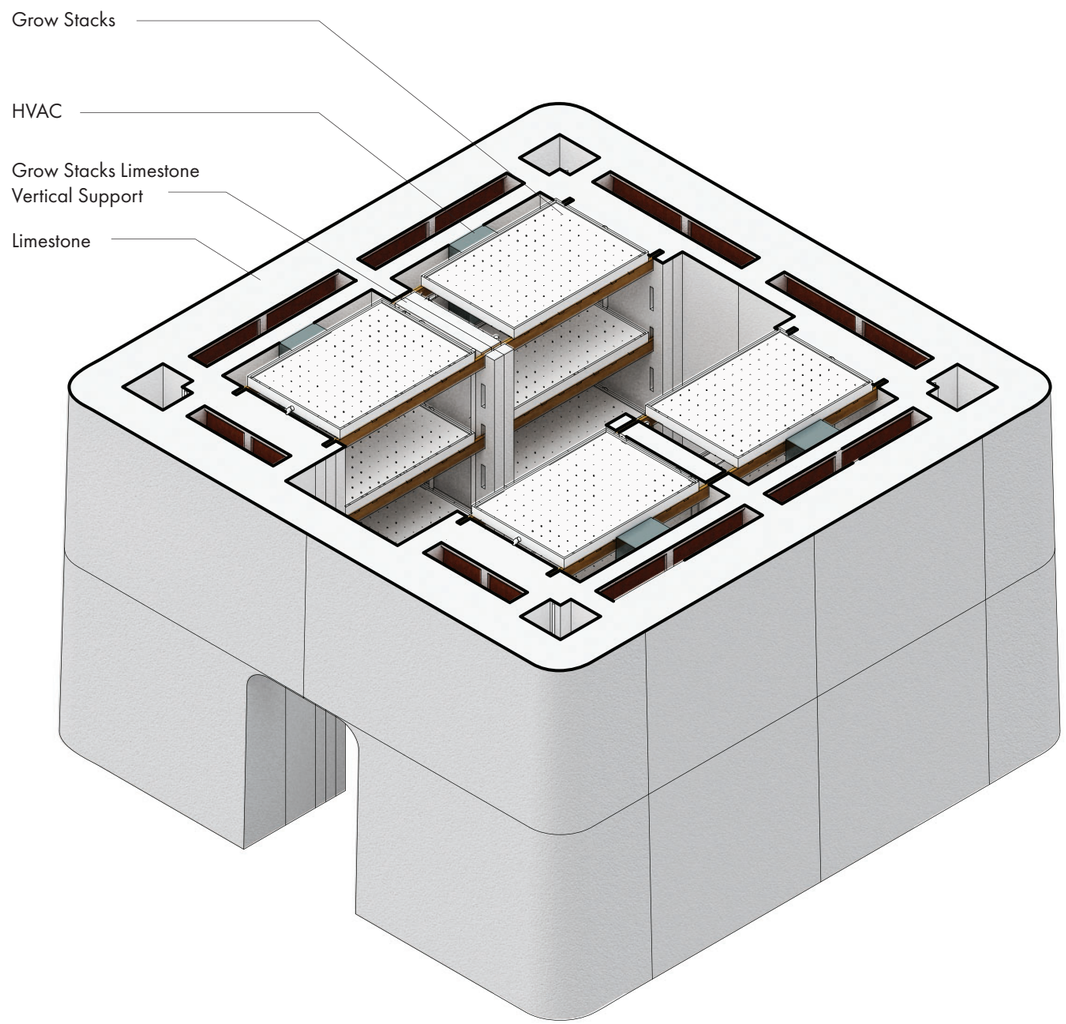
Components 3

Vertical Farm
Prefabricated Modules
Total Pieces: 88

Construction and Engineering Design Proposal

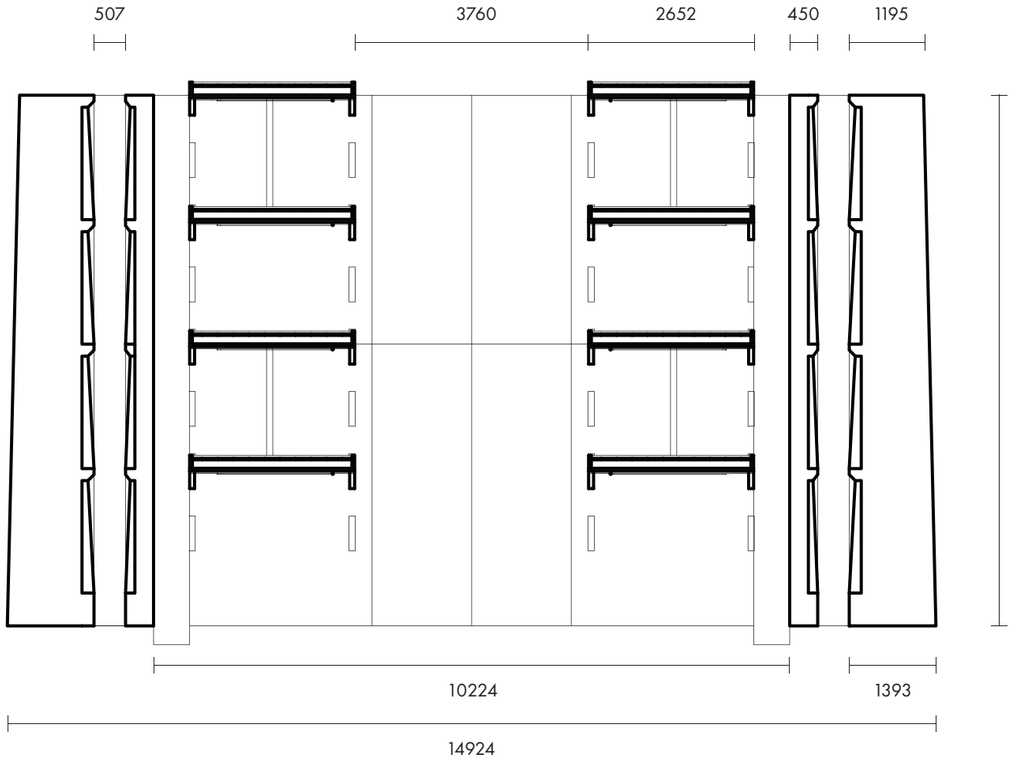
Aquaponics Vertical Farm Building Details

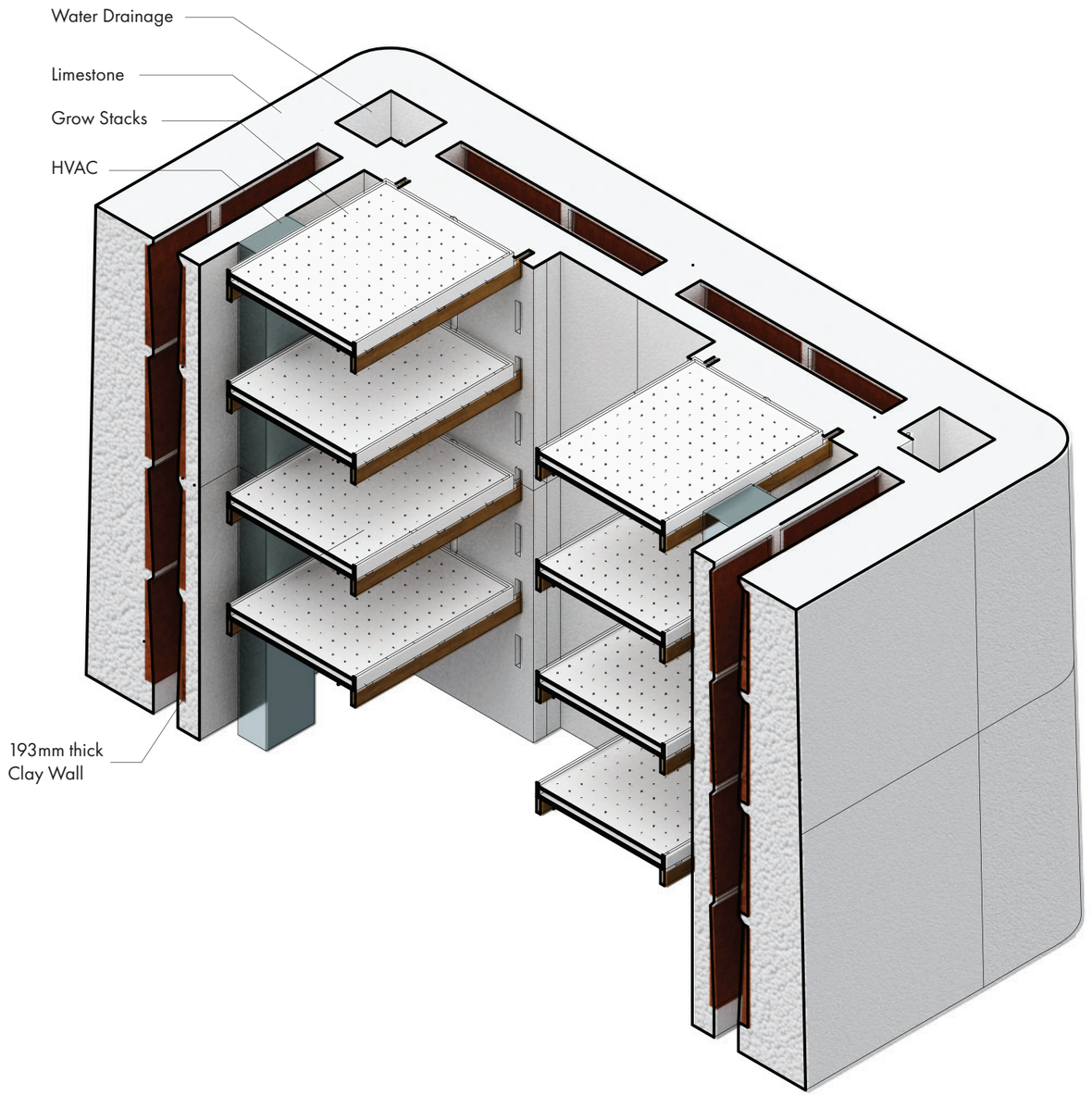




Construction and Engineering Design Proposal

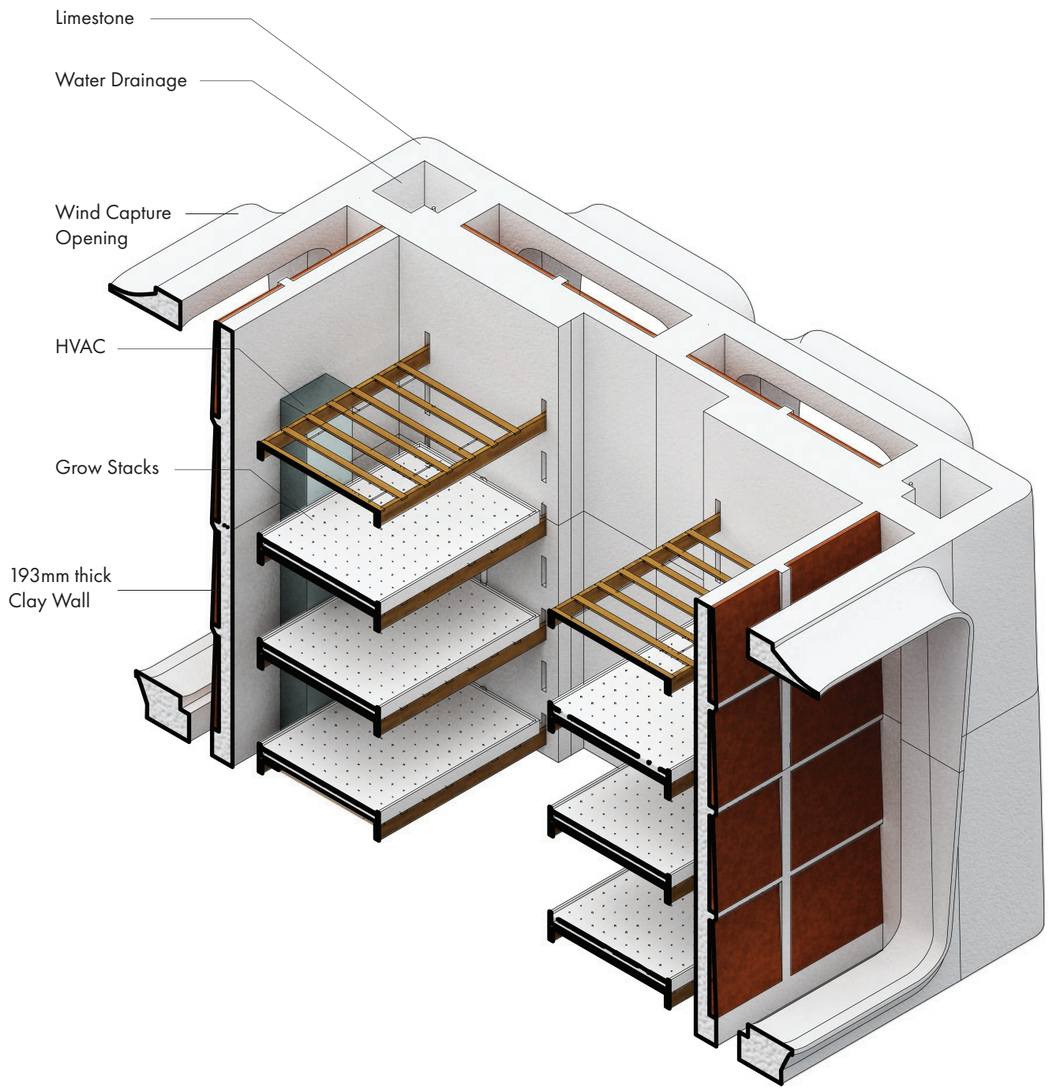
Aquaponics Vertical Farm Building Details



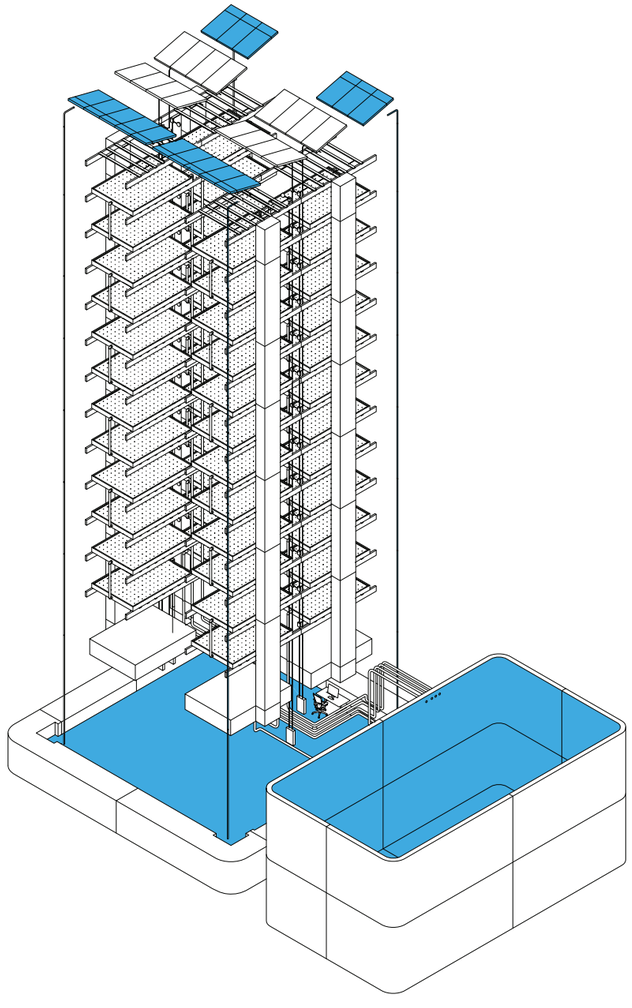


Construction and Engineering Design Proposal

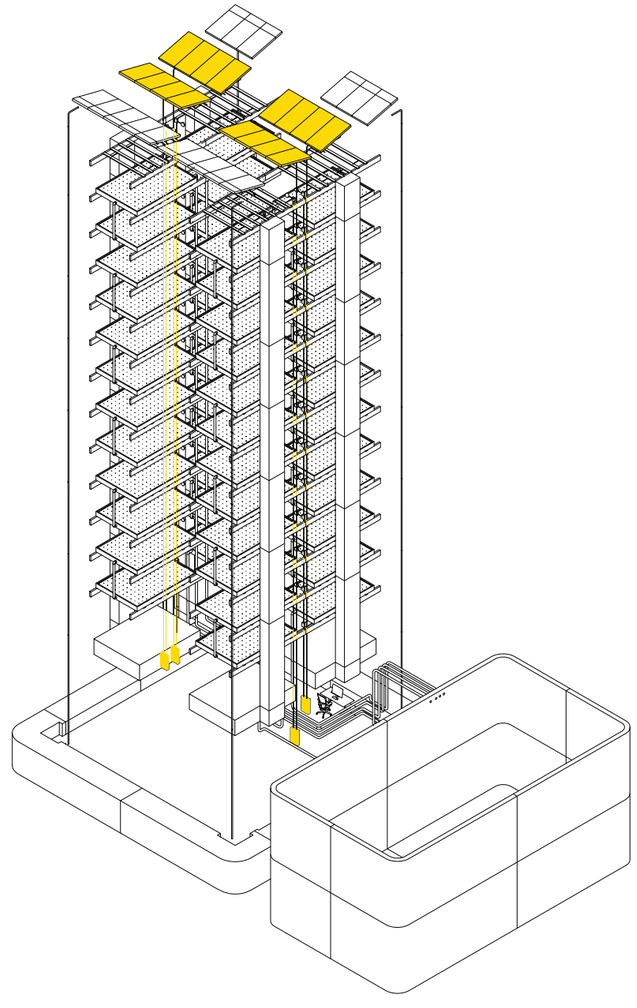
Aquaponics Vertical Farm Building Details



Aquaponics Vertical Farm Independent Systems

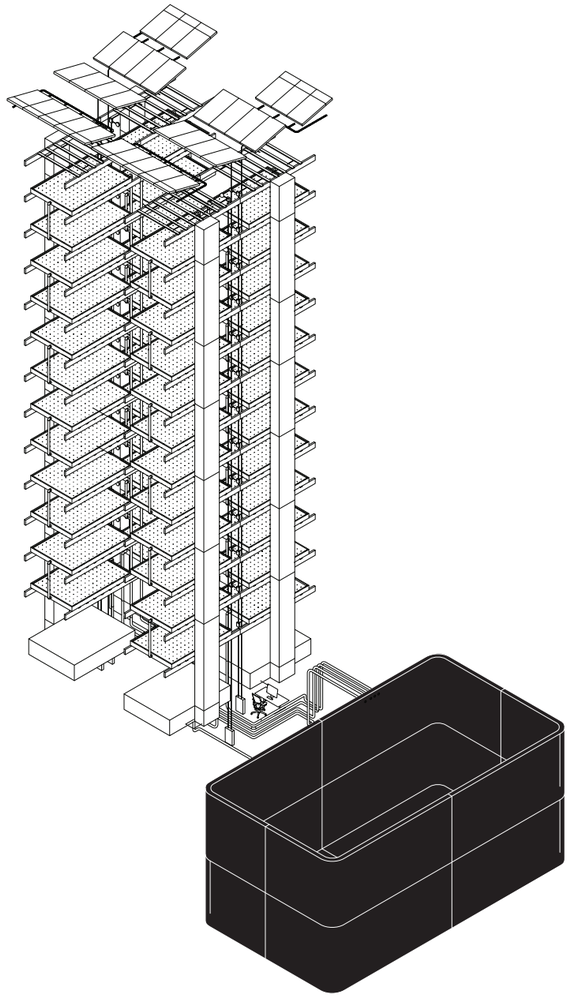


Hydro

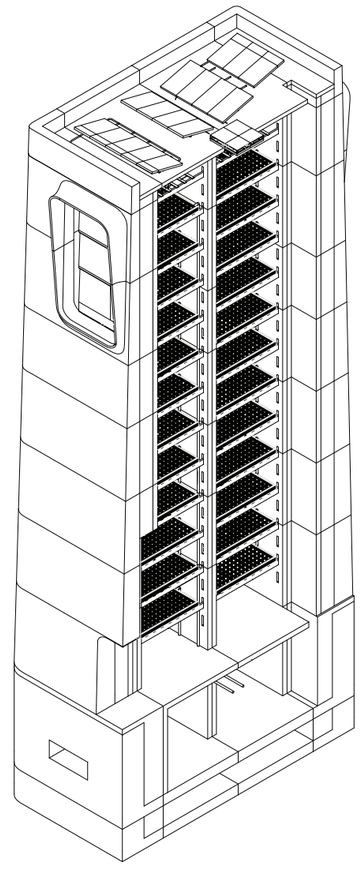


Solar

Aquaponics Vertical Farm Independent Systems

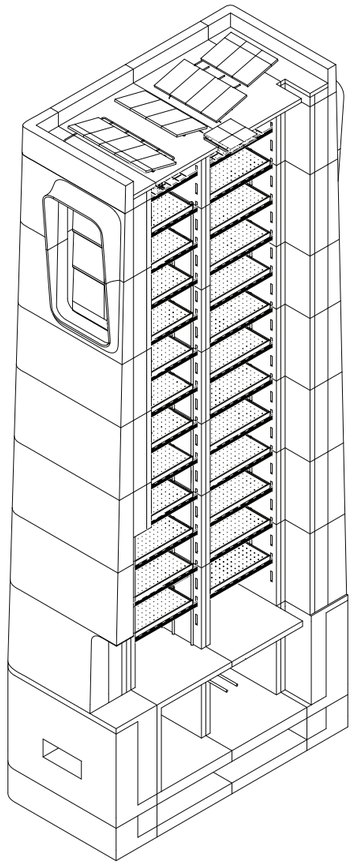


Permanent - Aquaponics Fish Tank

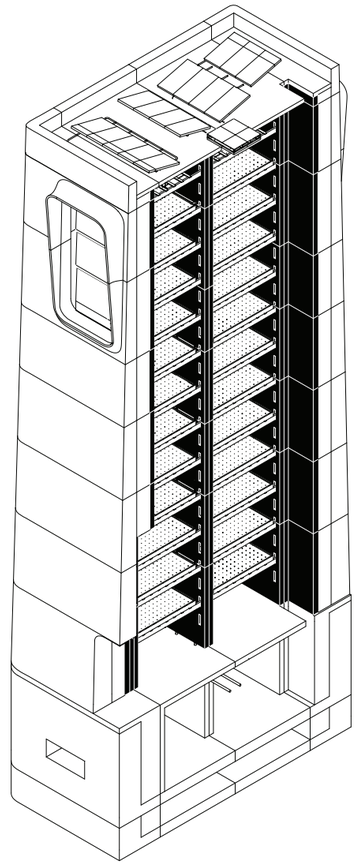


Temporary - Grow Stacks

Aquaponics Vertical Farm Independent Systems

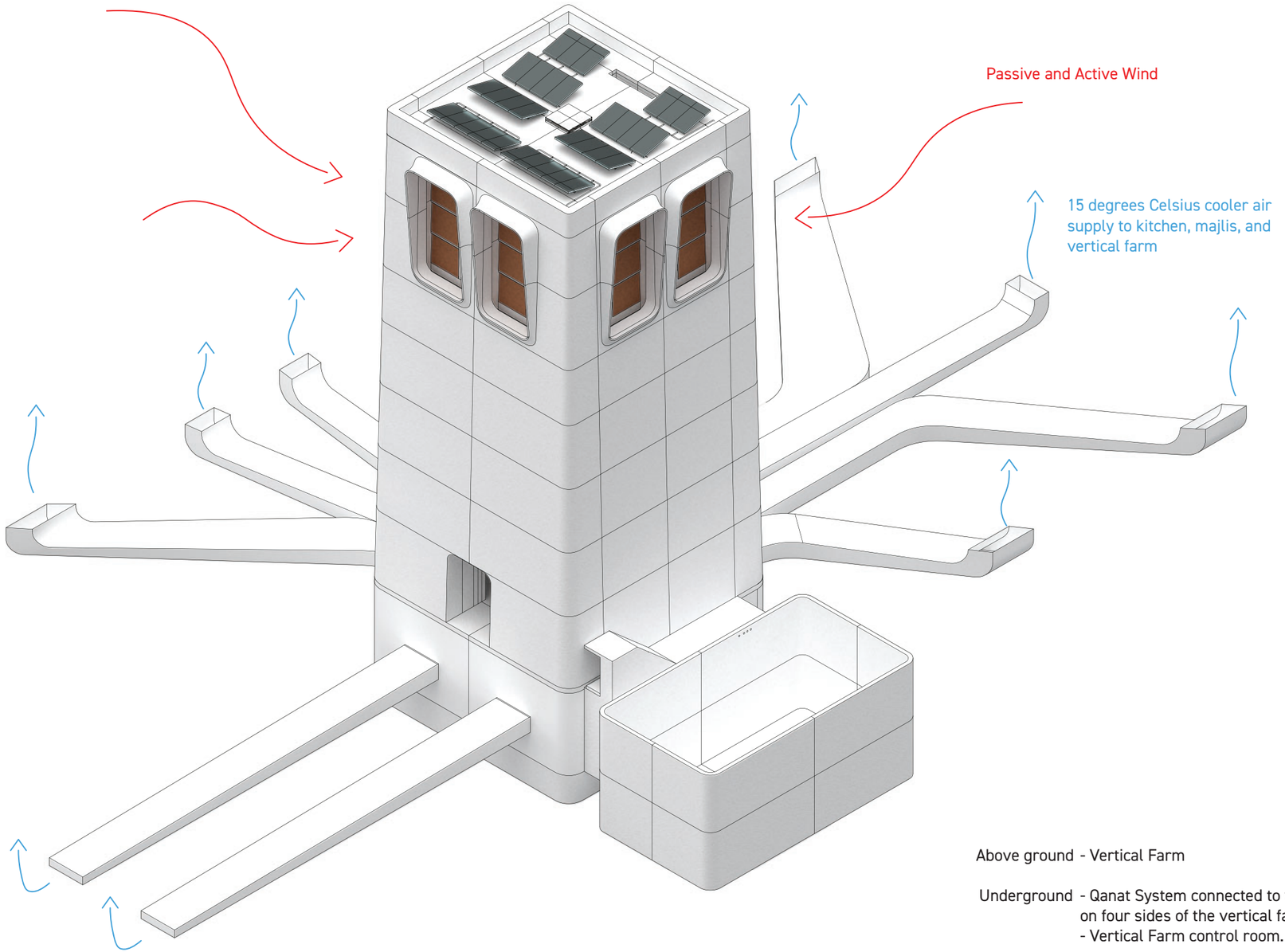


Temporary - Grow Stacks Wooden Support



Permanent - Limestone Grow Stacks Vertical Support

Aquaponics Vertical Farm Wind Supply

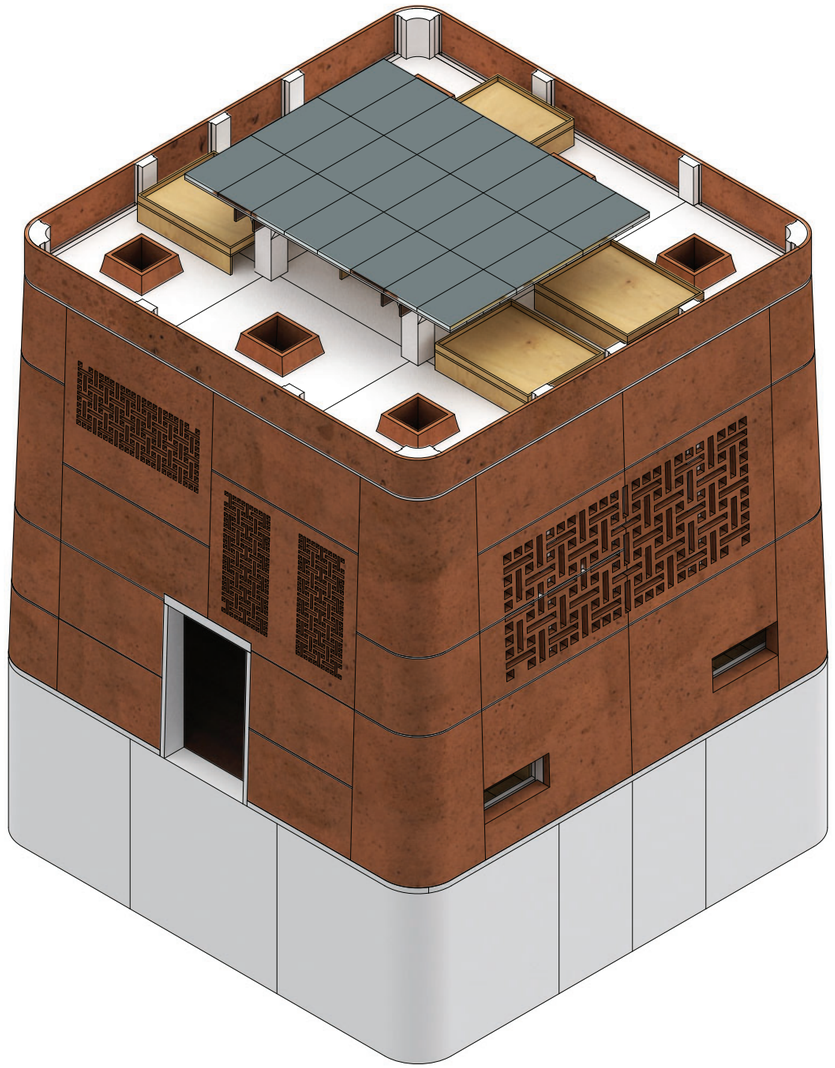


Above ground - Vertical Farm

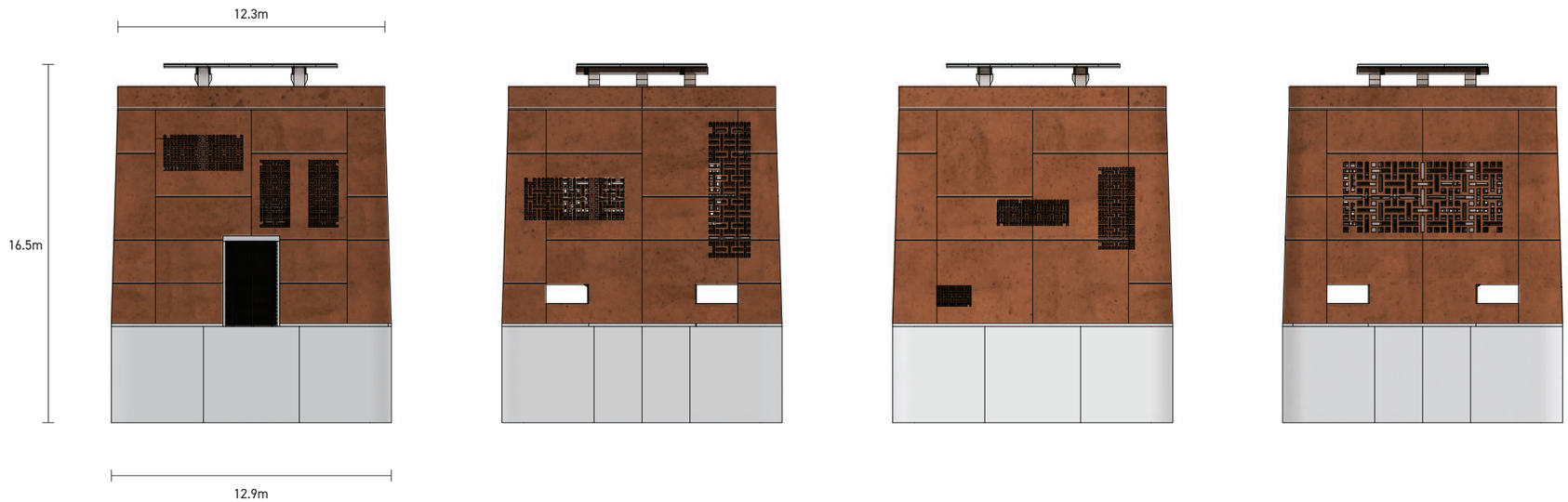
Underground - Qanat System connected to wind catcher on four sides of the vertical farm.
- Vertical Farm control room.

Construction and Engineering Design Proposal

Kitchen Instruction Manual



Elevations

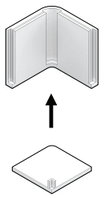


Foundation Assembly

01

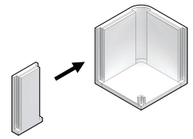
Limestone Foundation Walls and Floor Assembly Guide

02



03

04



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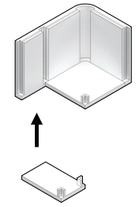

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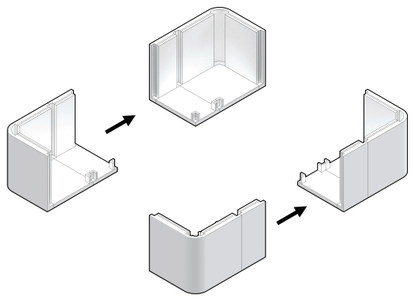

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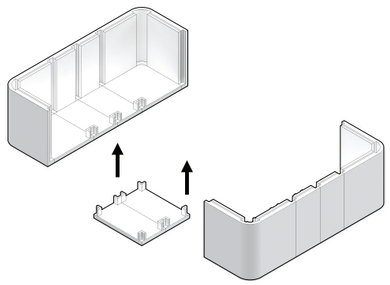

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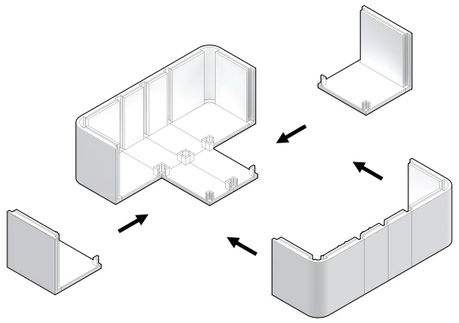

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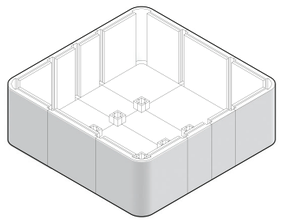

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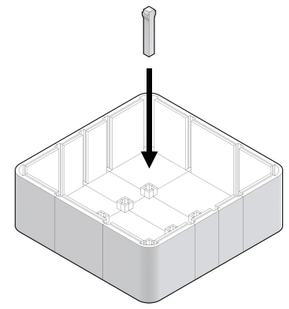
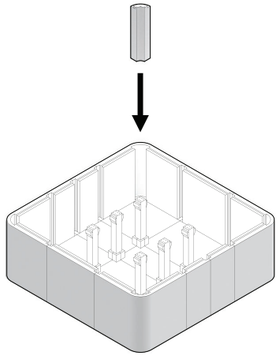


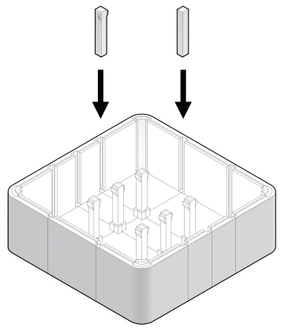
Internal Structure

11



Limestone Foundation Walls and Floor Assembly Guide

12



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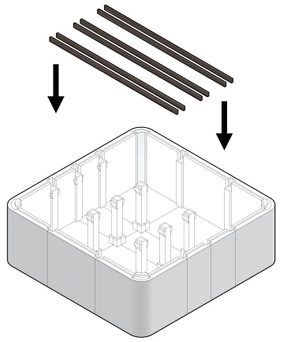

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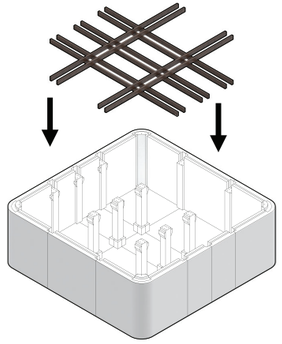

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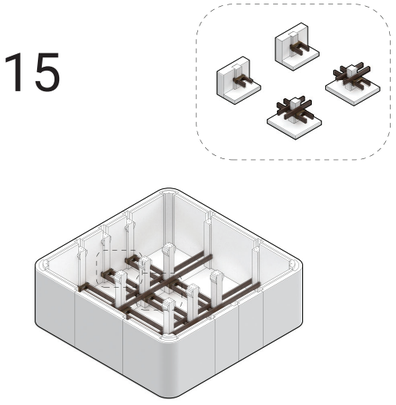

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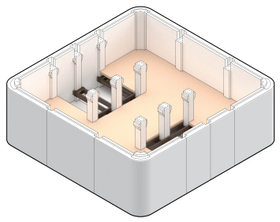

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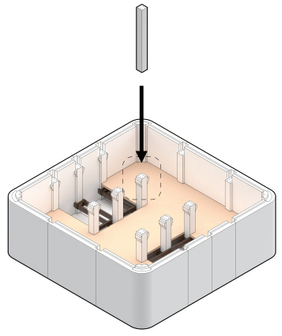

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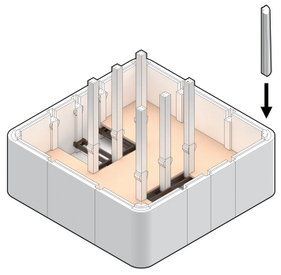

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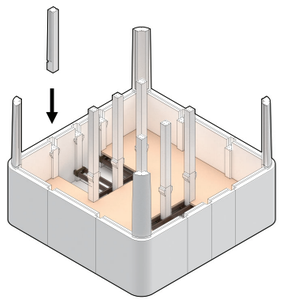

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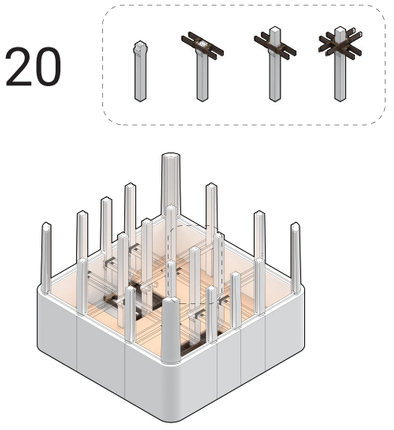
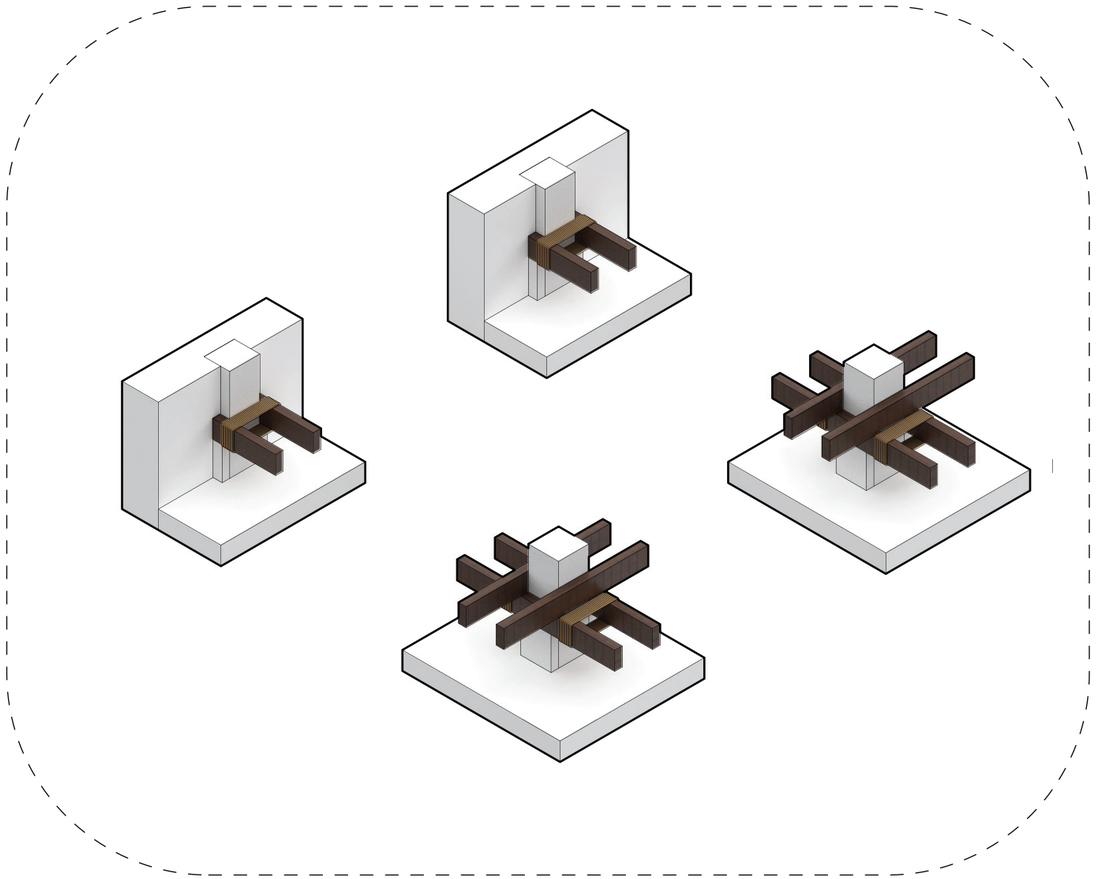
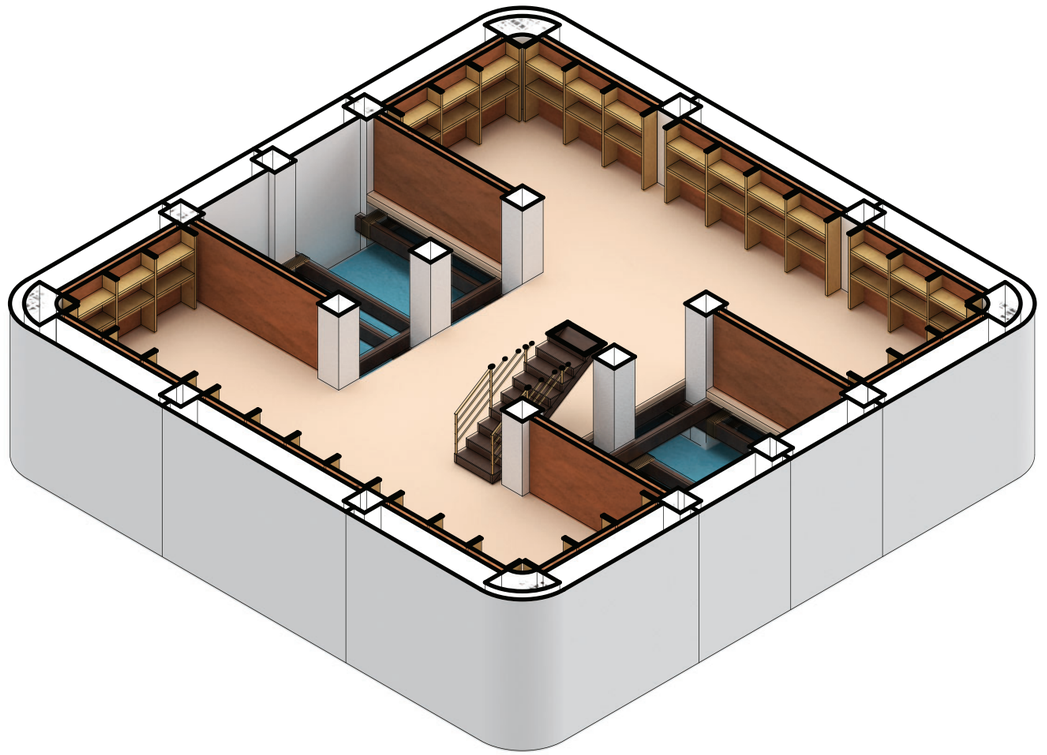


Cold Storage





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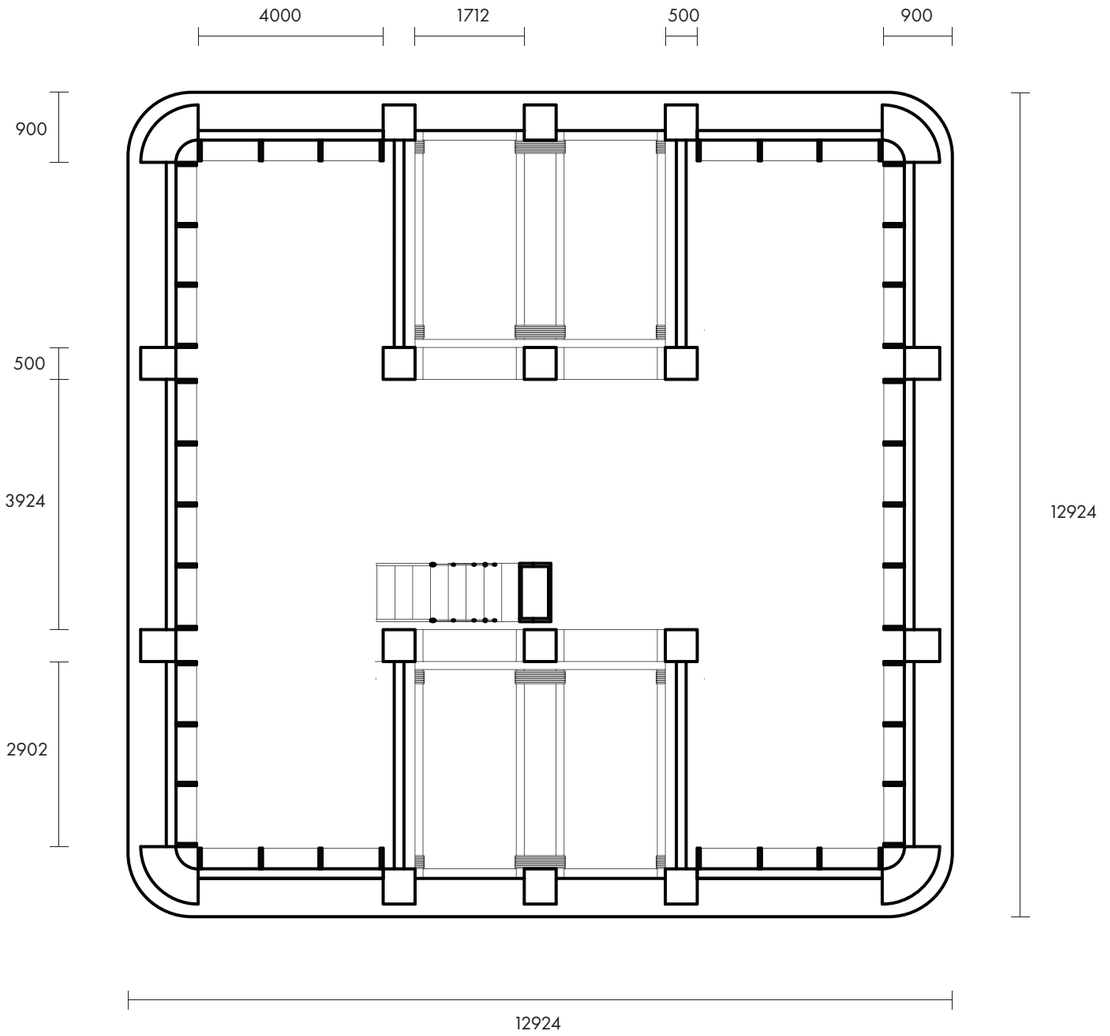
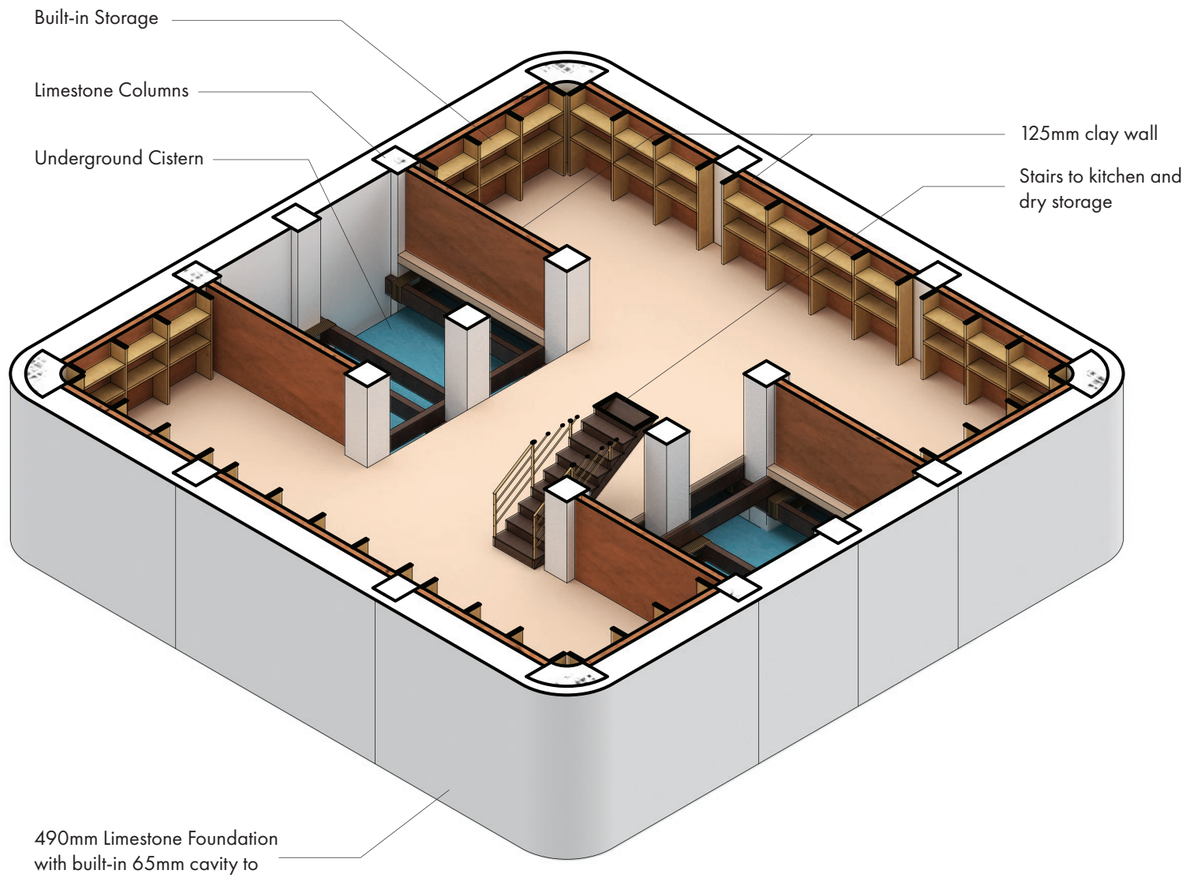
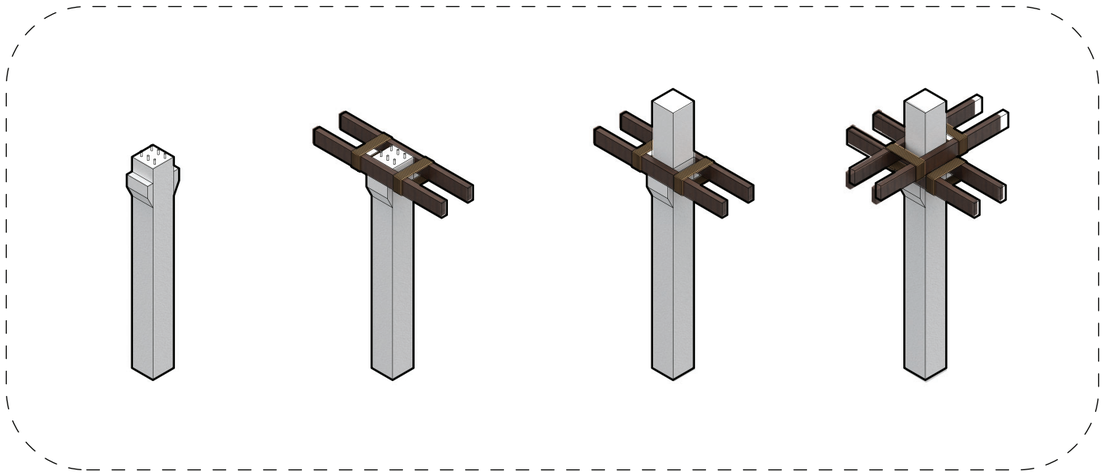
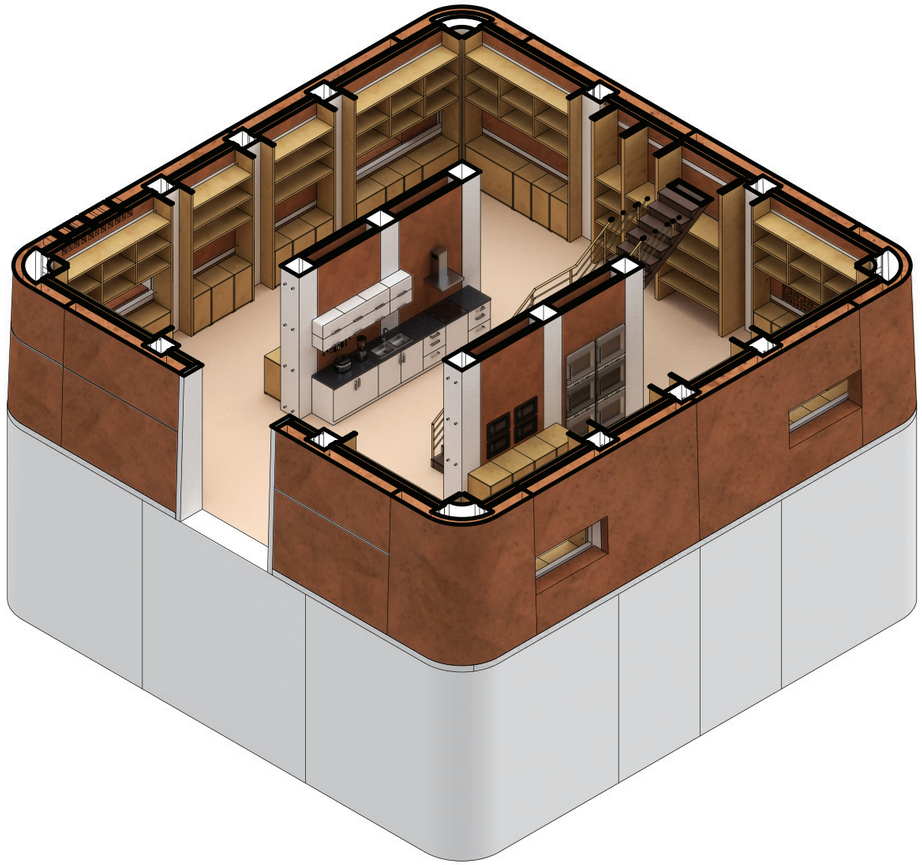
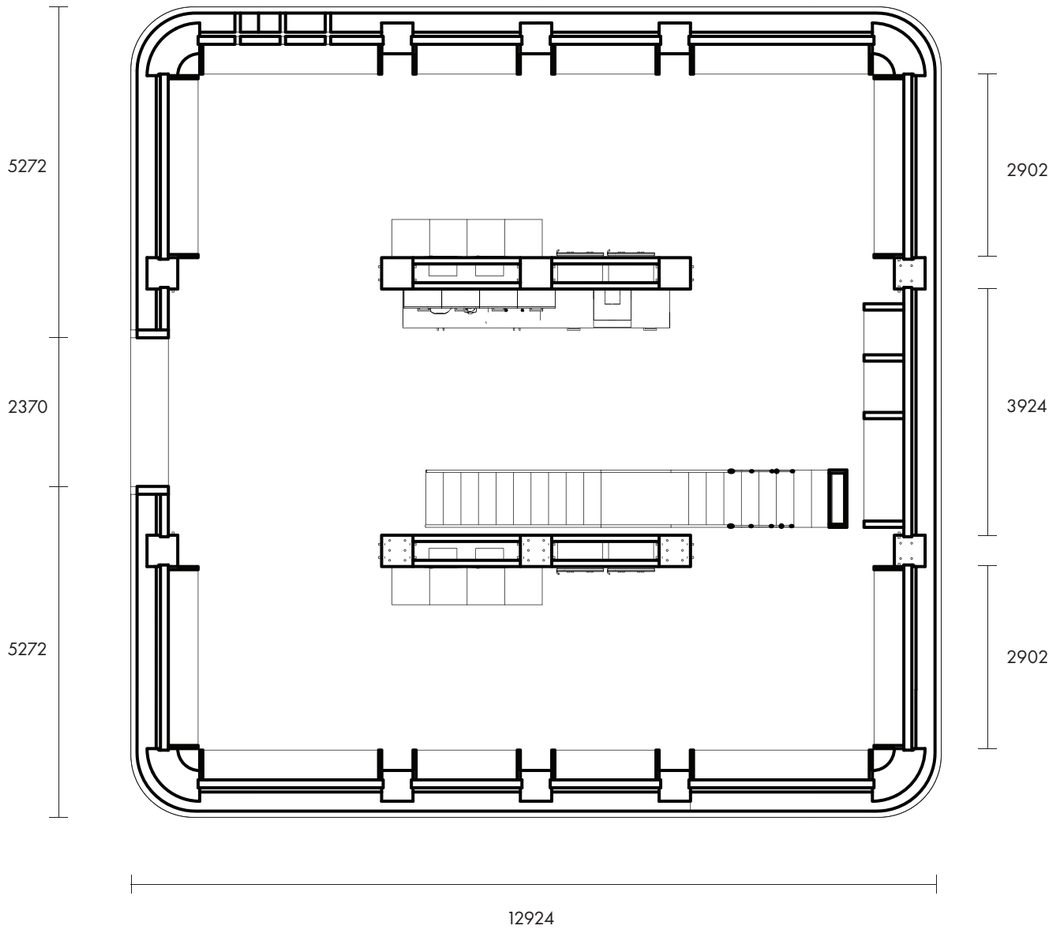








Kitchen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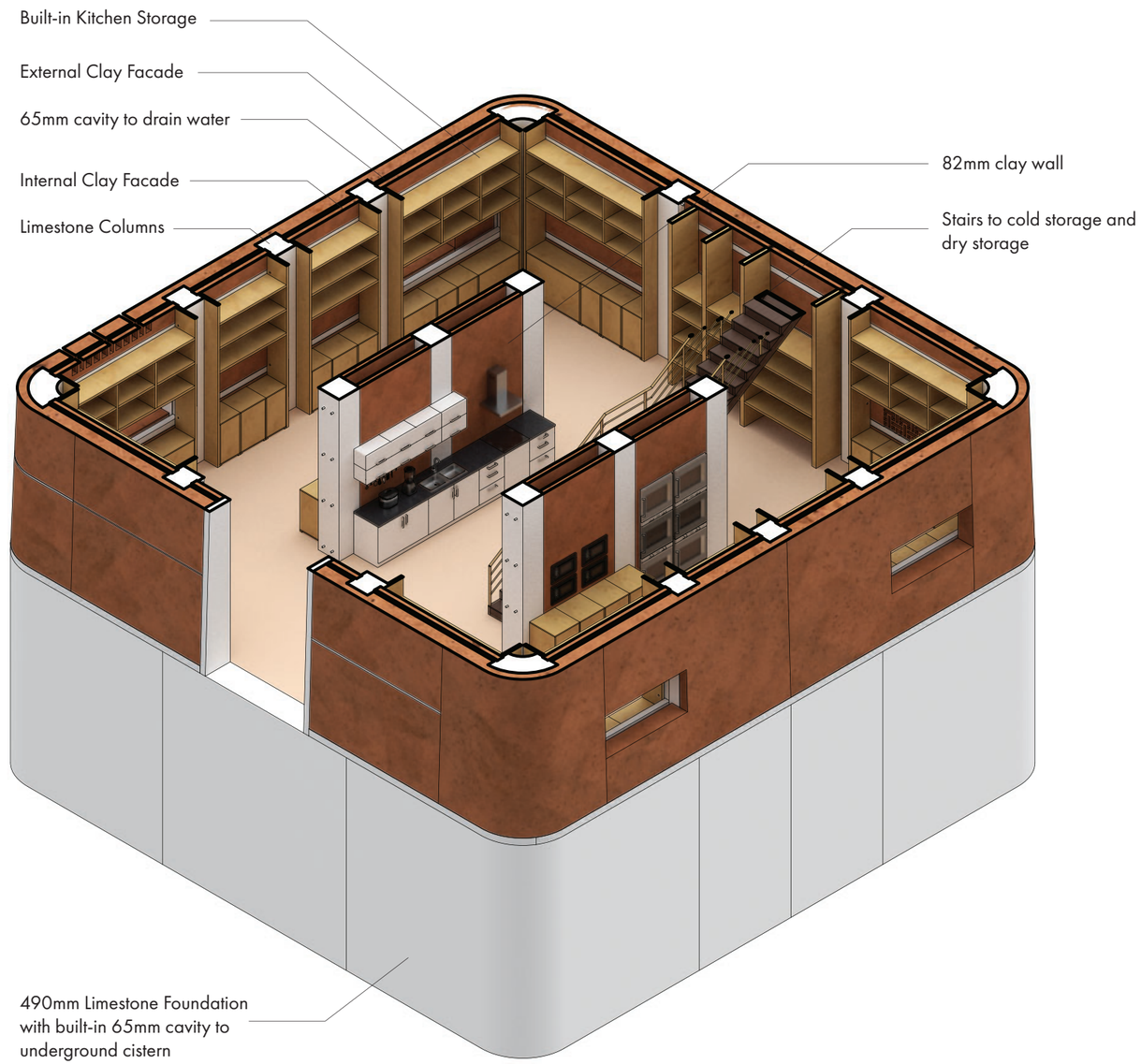
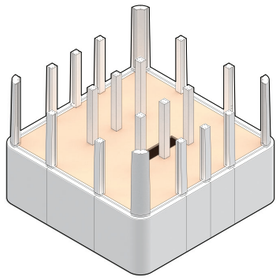

Built-in Kitchen Storage
External Clay Facade
65mm cavity to drain water
Internal Clay Facade
Limestone Columns
82mm clay wall
Stairs to cold storage and dry storage
490mm Limestone Foundation with built-in 65mm cavity to underground cistern

Facade Assembly

21



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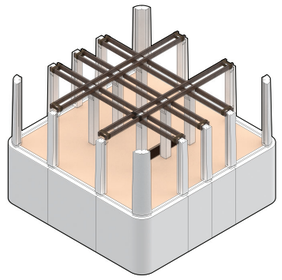

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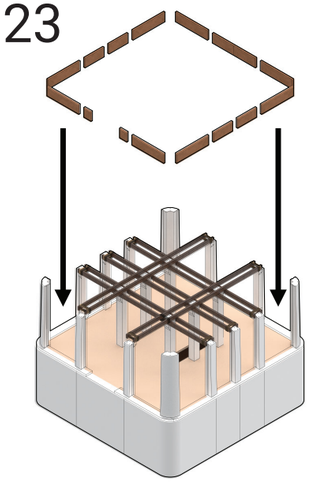

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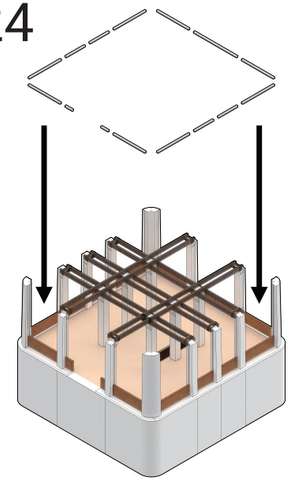

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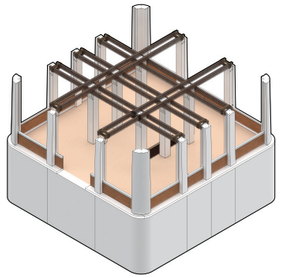

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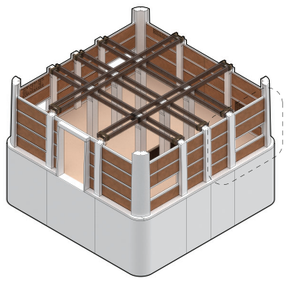

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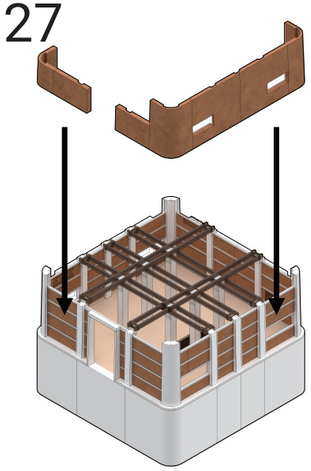

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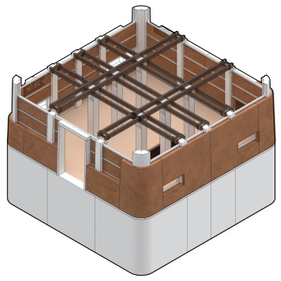

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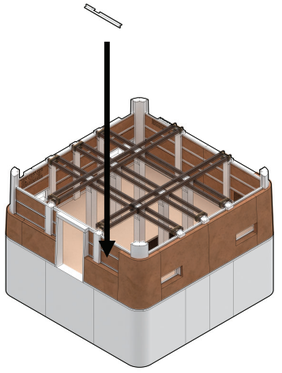

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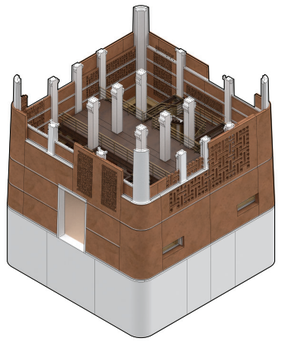

Roof Assembly

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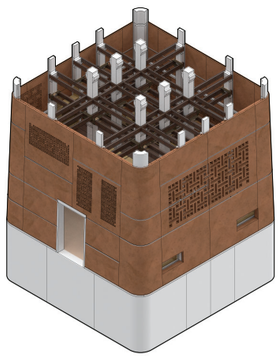

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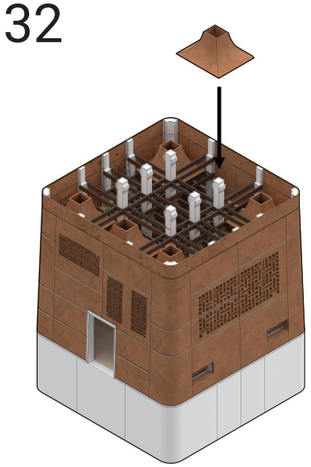

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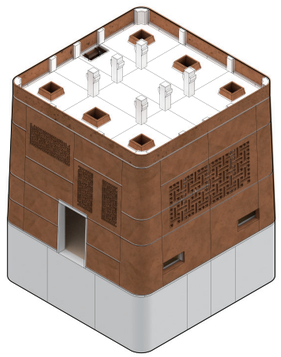

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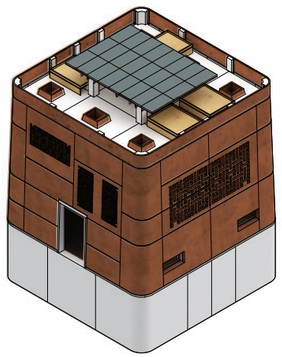
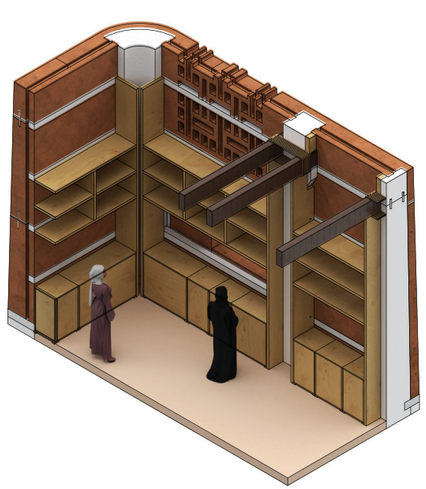
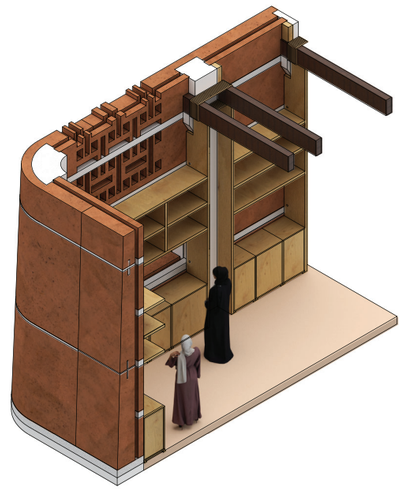
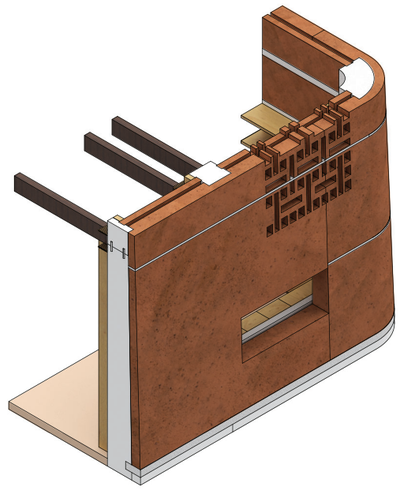
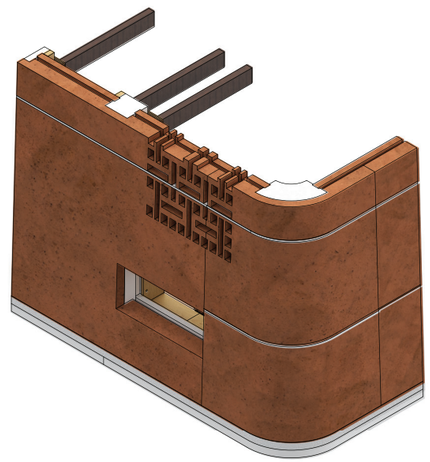


Kitchen Micro Chunk



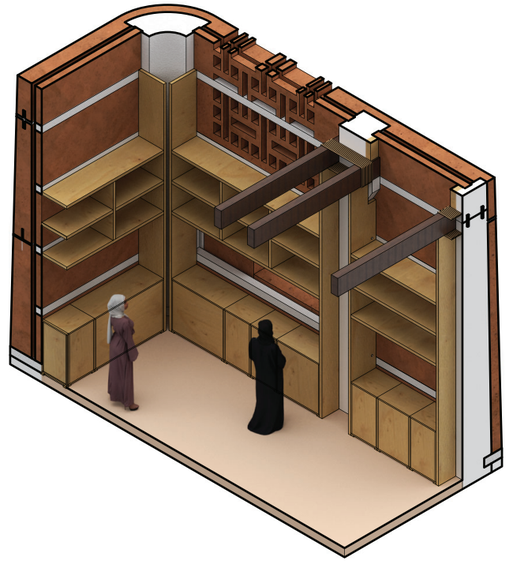


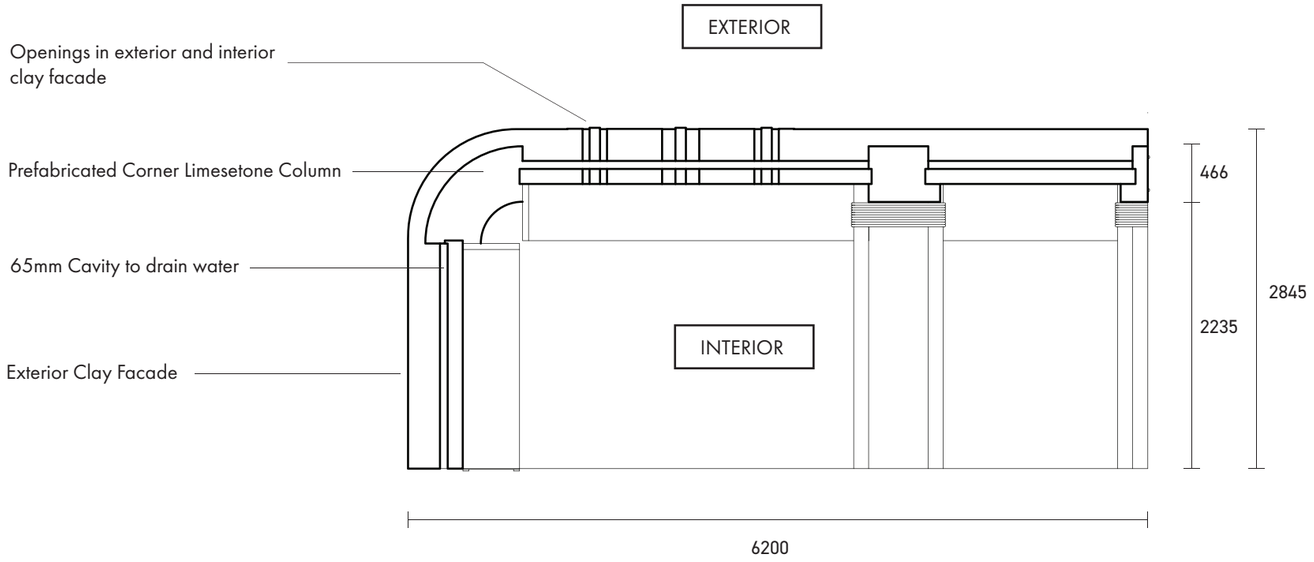


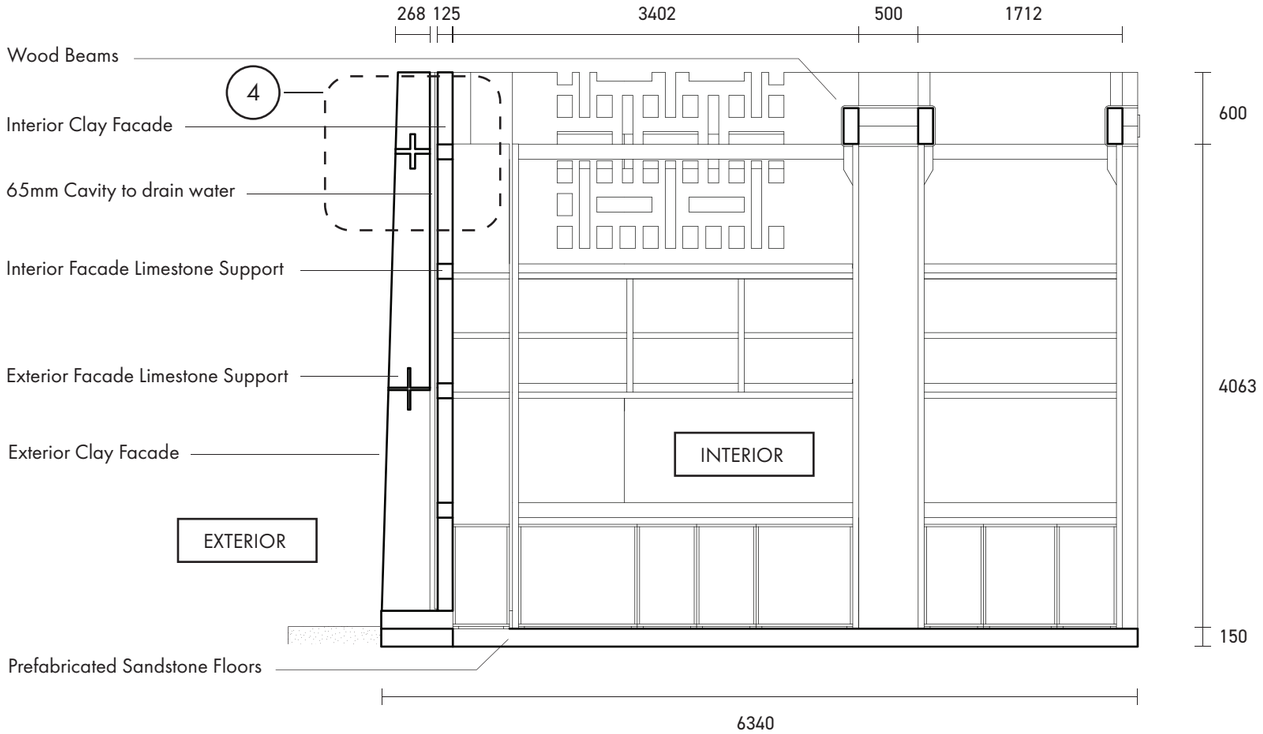


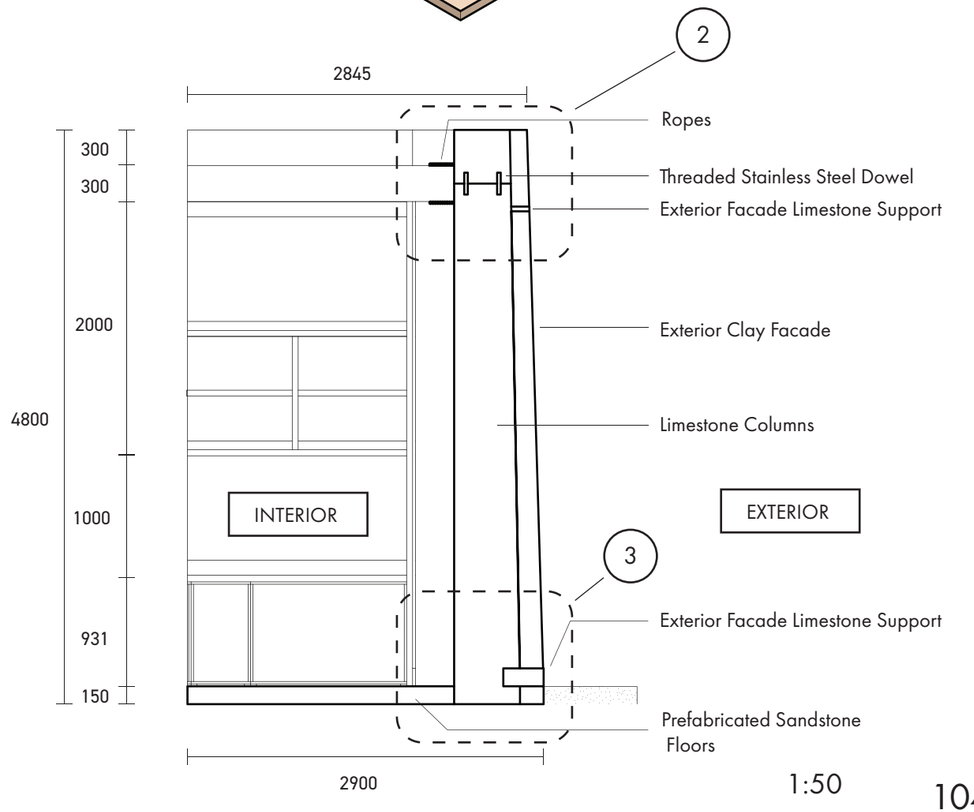
Construction and Engineering Design Proposal

Kitchen Independent Systems









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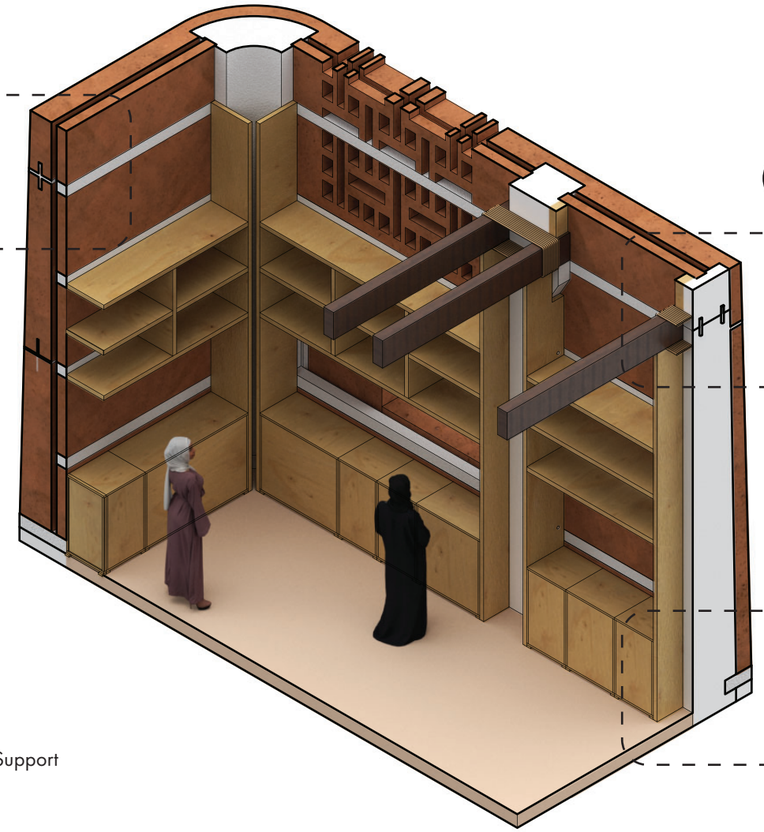
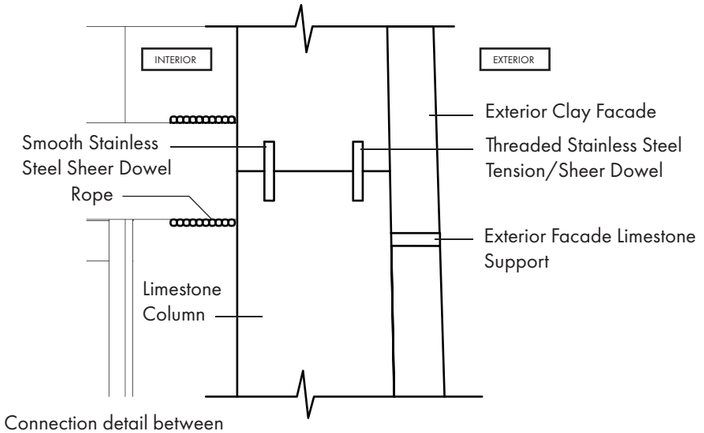
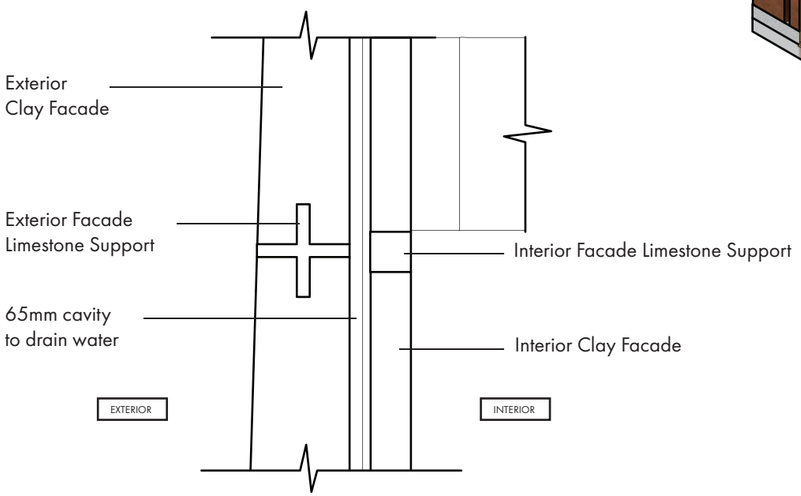
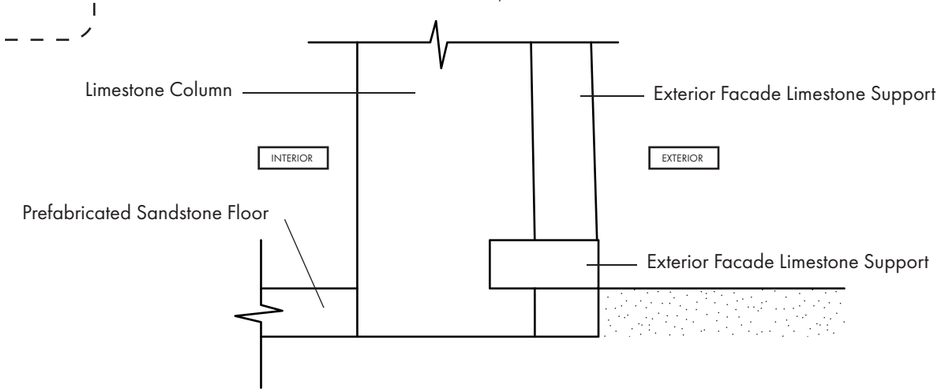




2 Connection detail between two limestone columns

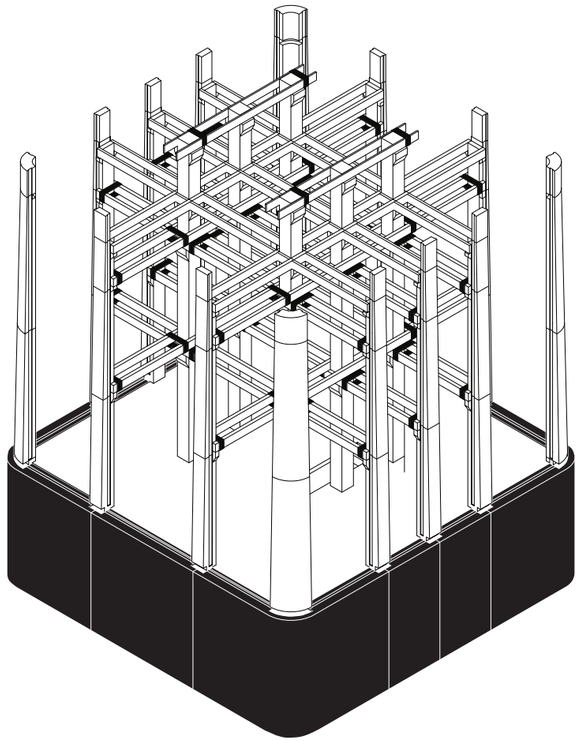


4 Clay Facade and Interior Clay Wall Detail

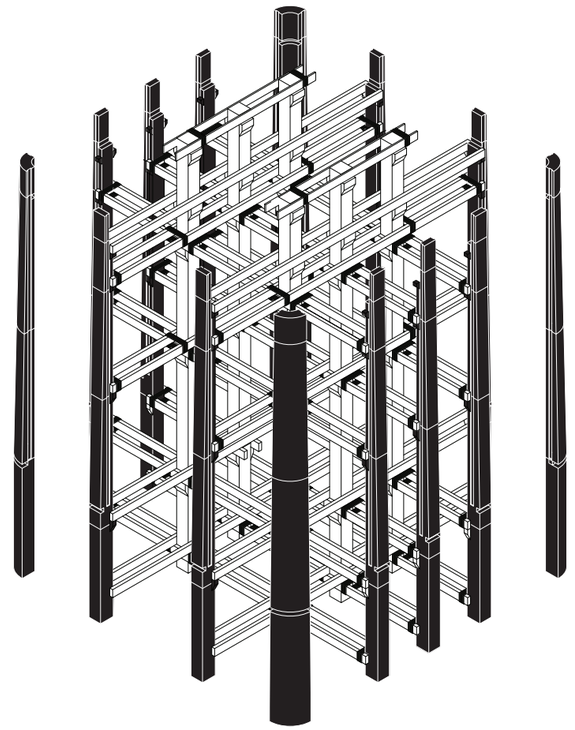


3 Limestone Column connection to sand

Kitchen Independent Systems

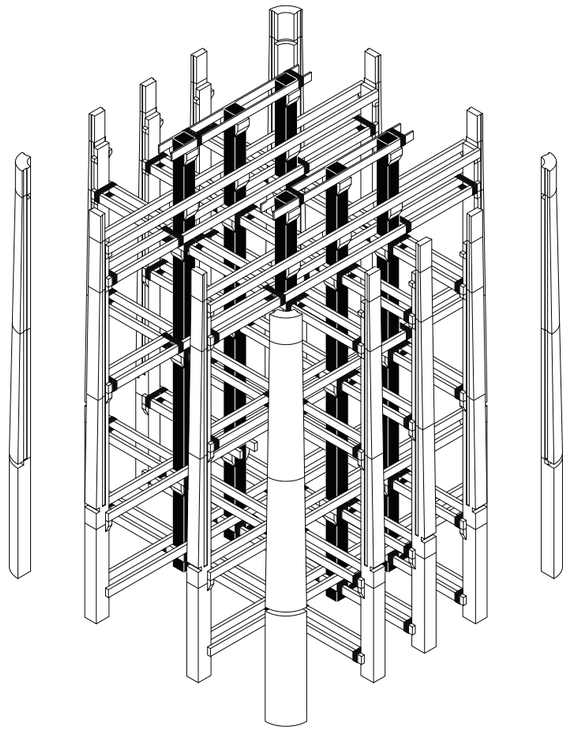


Permanent - Limestone Foundation

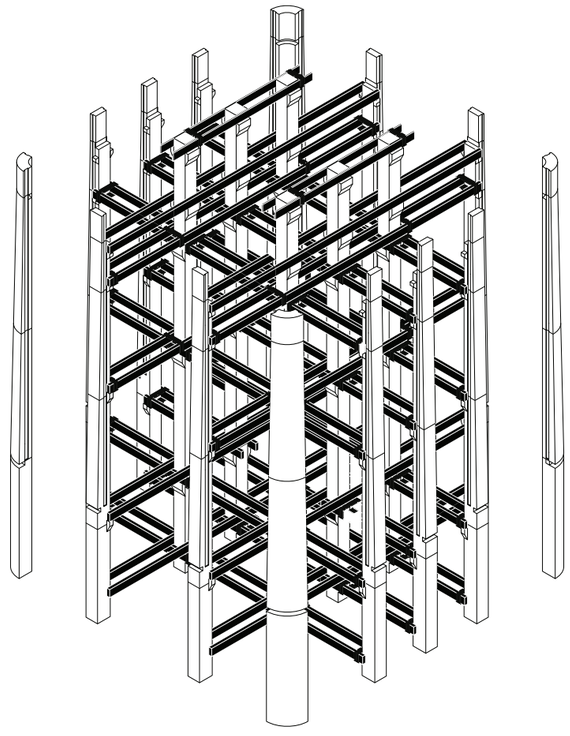


Permanent - Limestone Columns

Kitchen Independent Systems

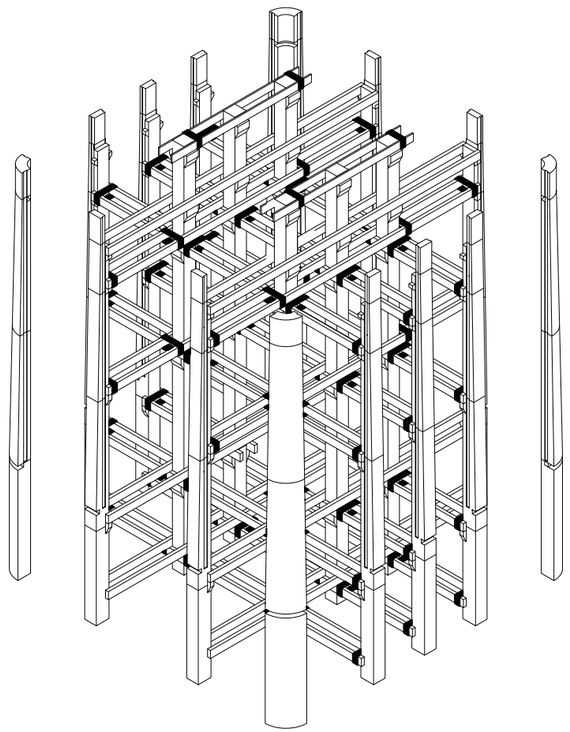


Permanent - Limestone Columns

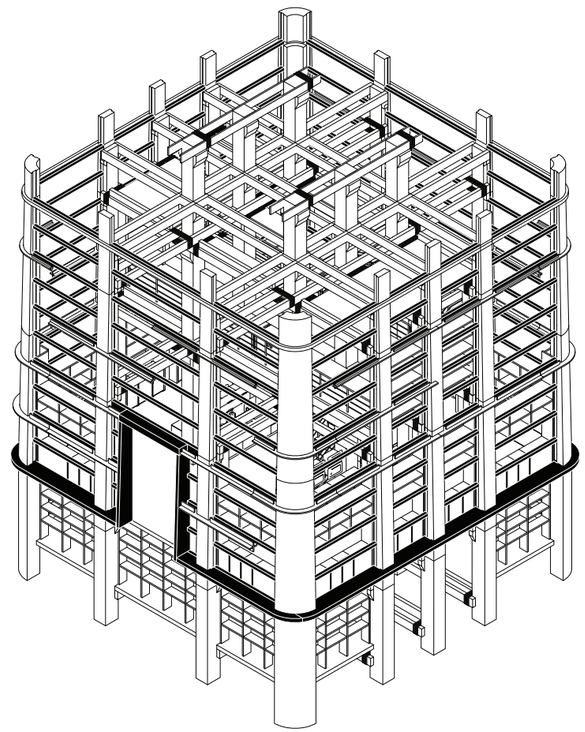


Temporary - Wood Beams

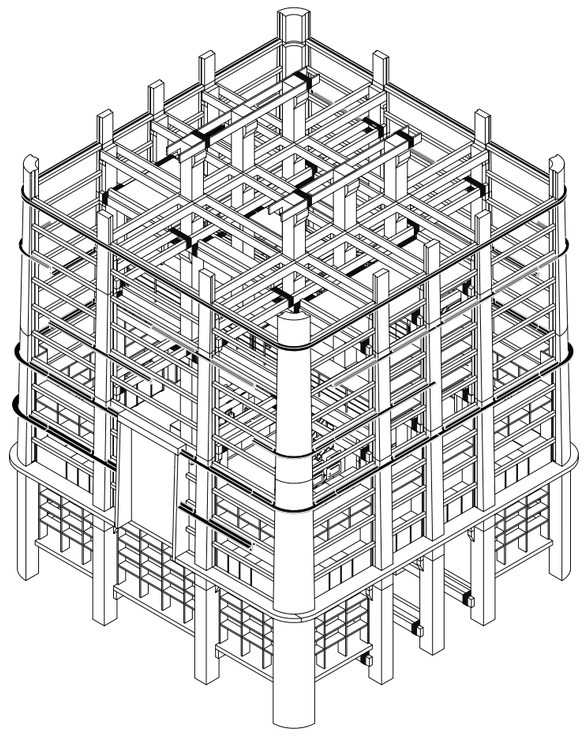
Kitchen Independent Systems



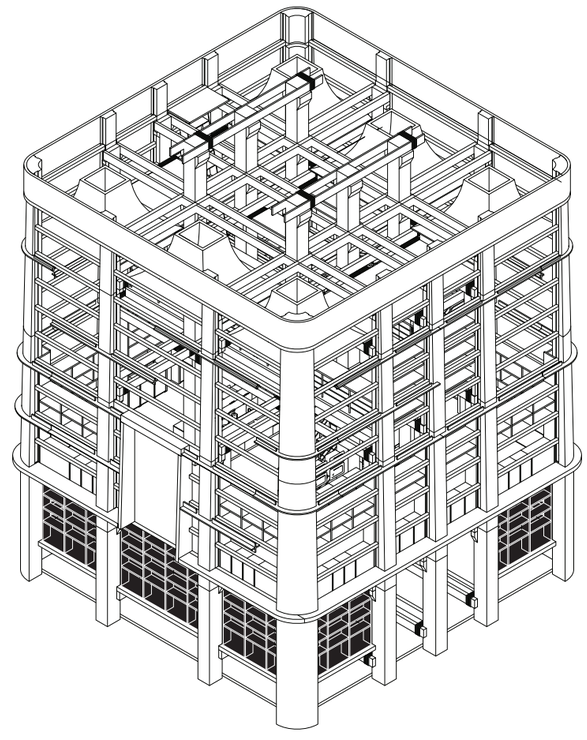
Temporary - Ropes



Temporary - Limestone Interior Facade Stabilizer

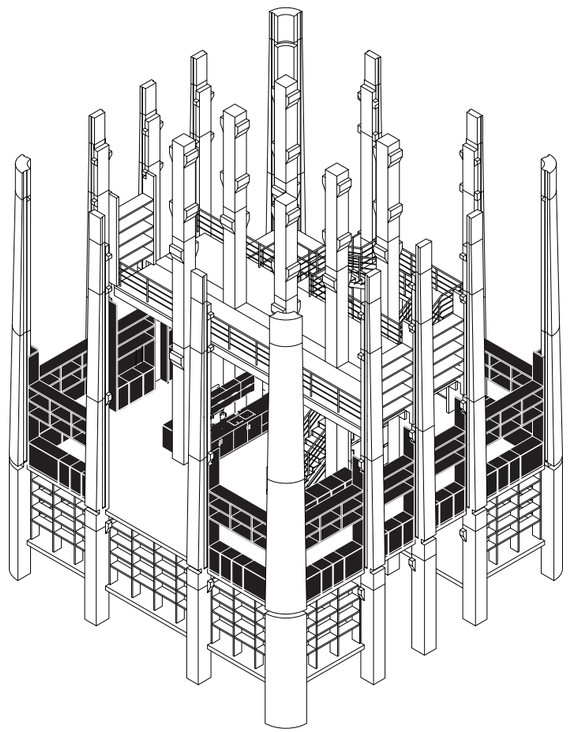


Temporary - Limestone Exterior Facade Stabilizer

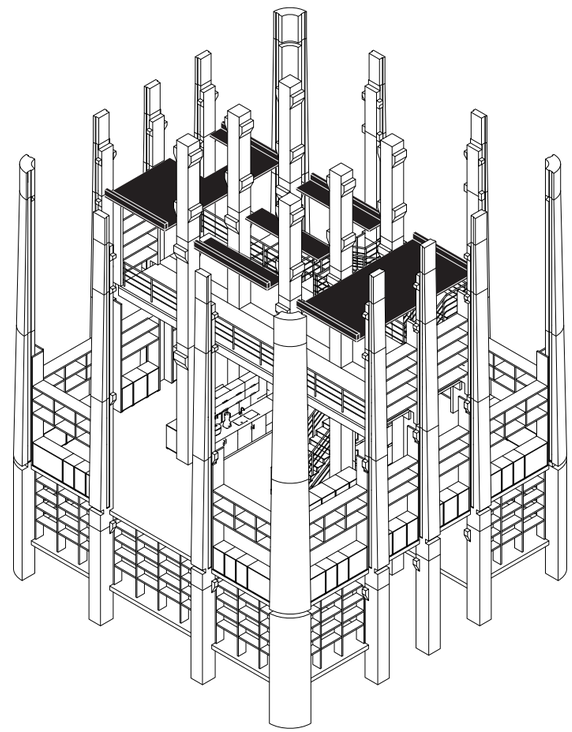


Cold Storage

Kitchen Independent Systems

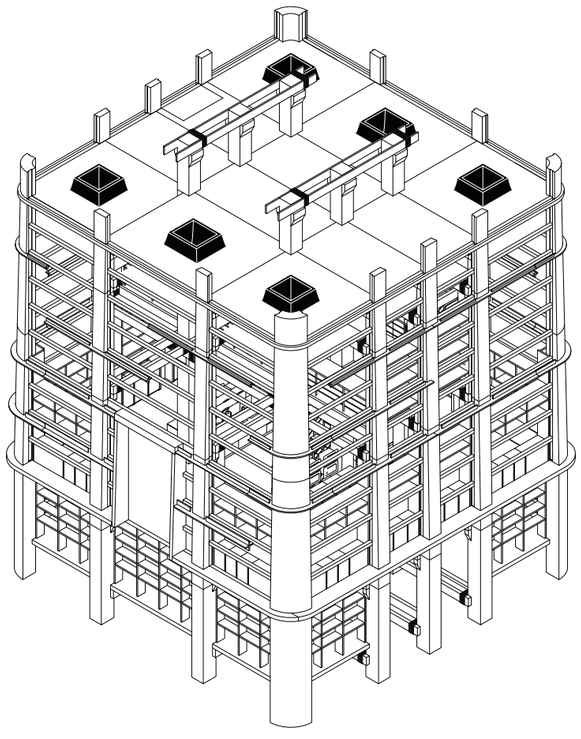


Kitchen

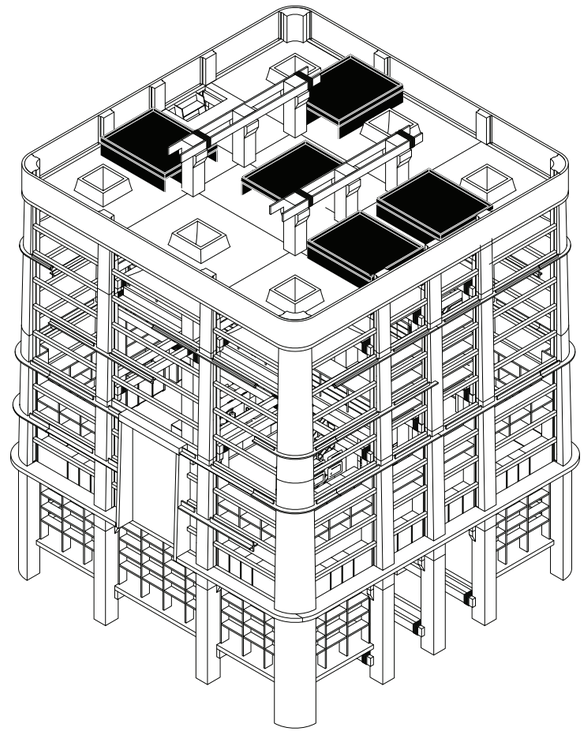


Dry Storage

Kitchen Independent Systems

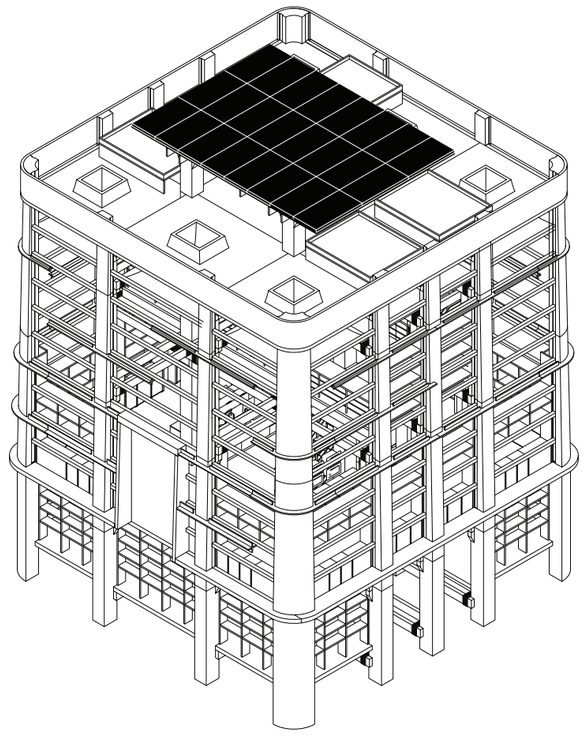


Permanent - Cob Chimneys

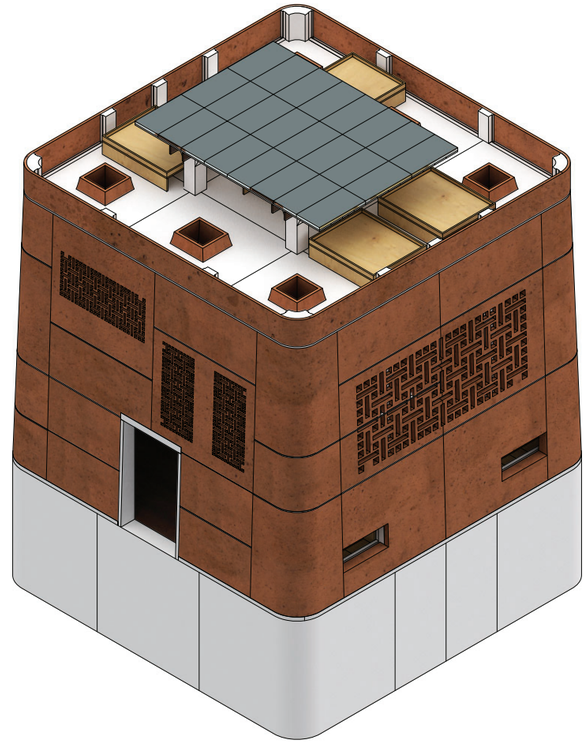


Temporary - Roof Vegetable Garden

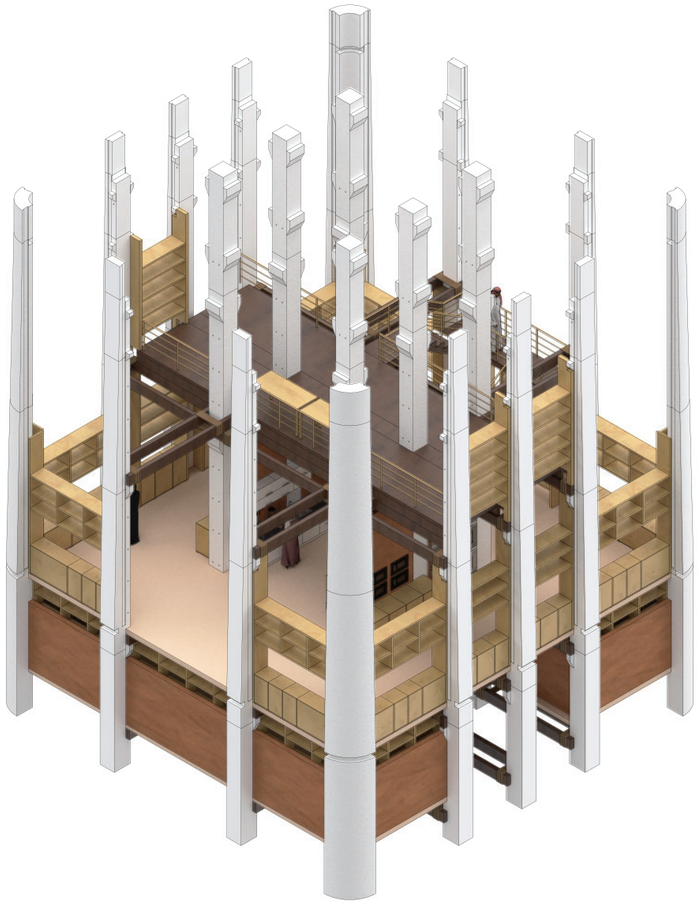
Kitchen Independent Systems



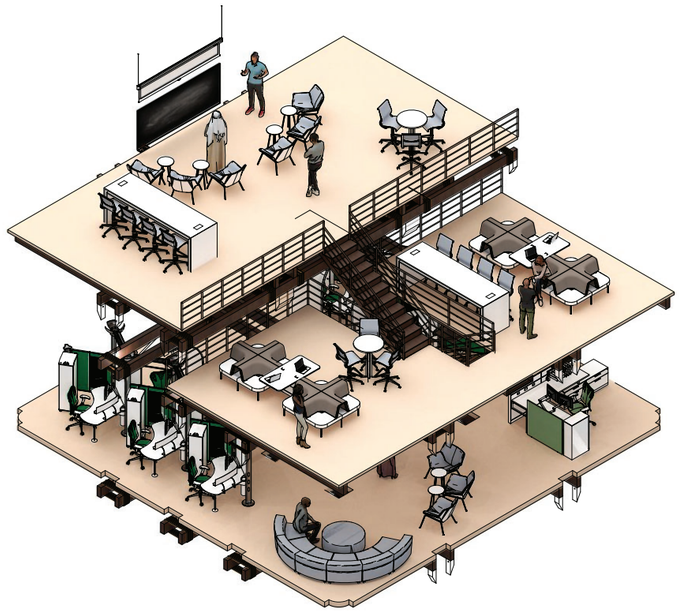
Temporary - Solar and Hydro Panels

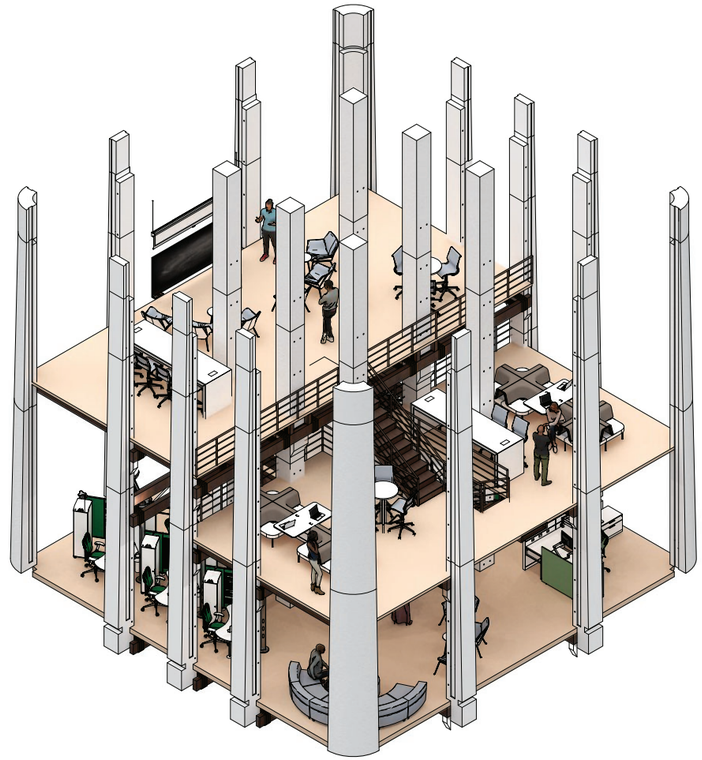


Kitchen



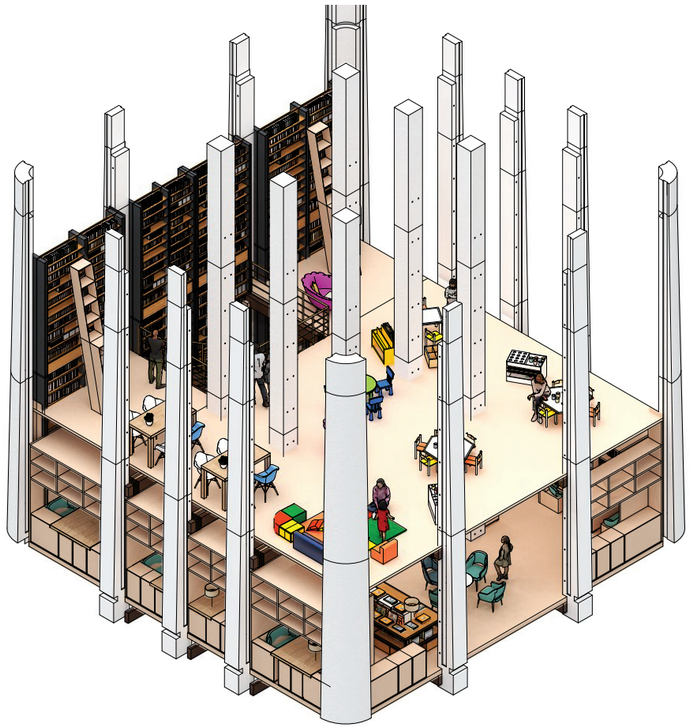
New Program - A.I. Startup





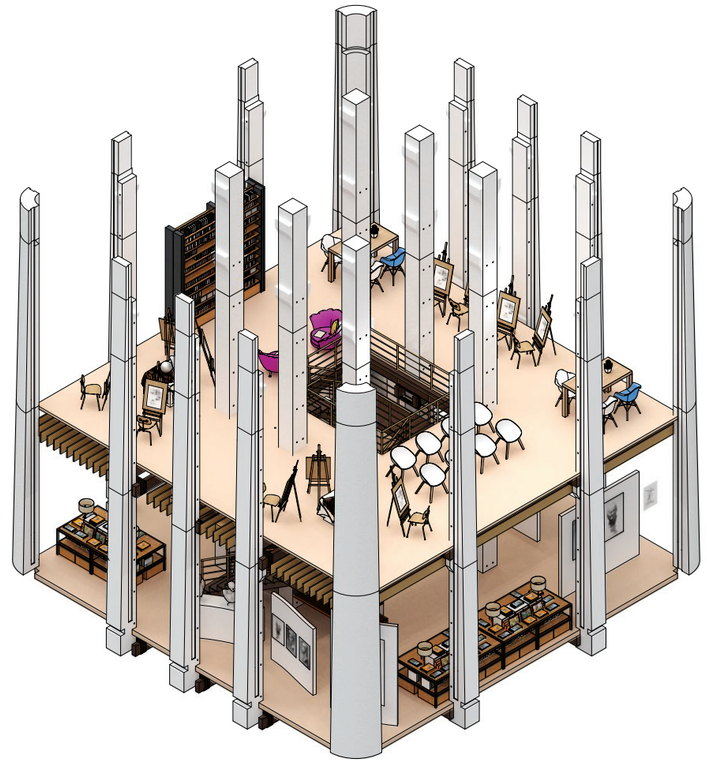
Construction and Engineering Design Proposal

New Program - Education Center

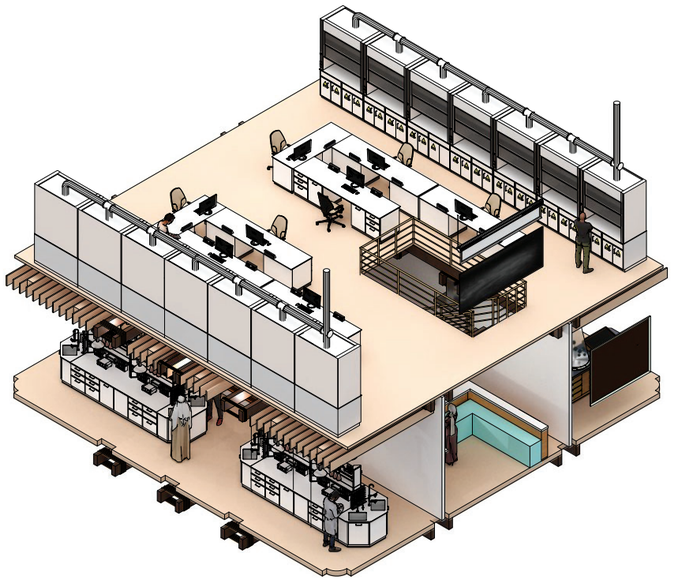


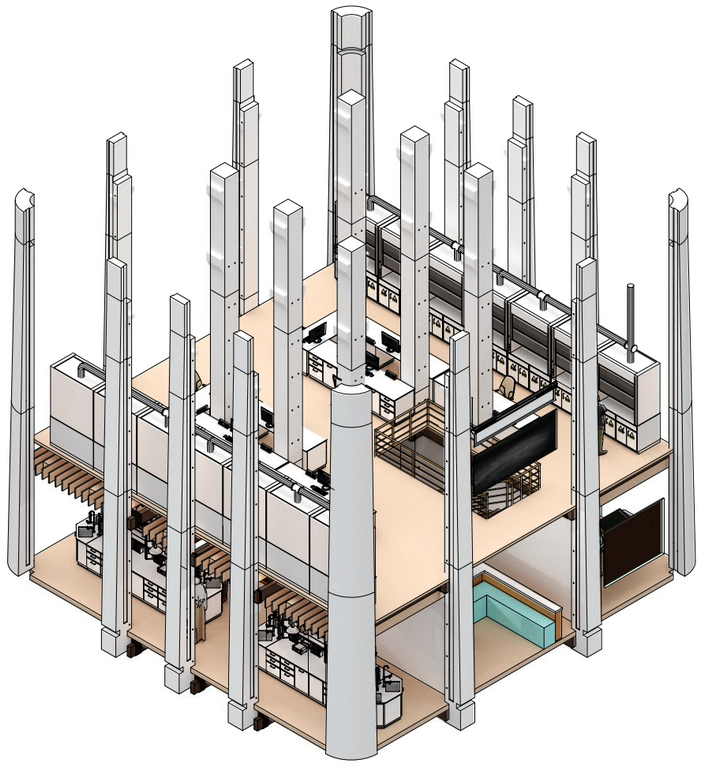
New Program - Farm Extension

New Program - Gallery Center



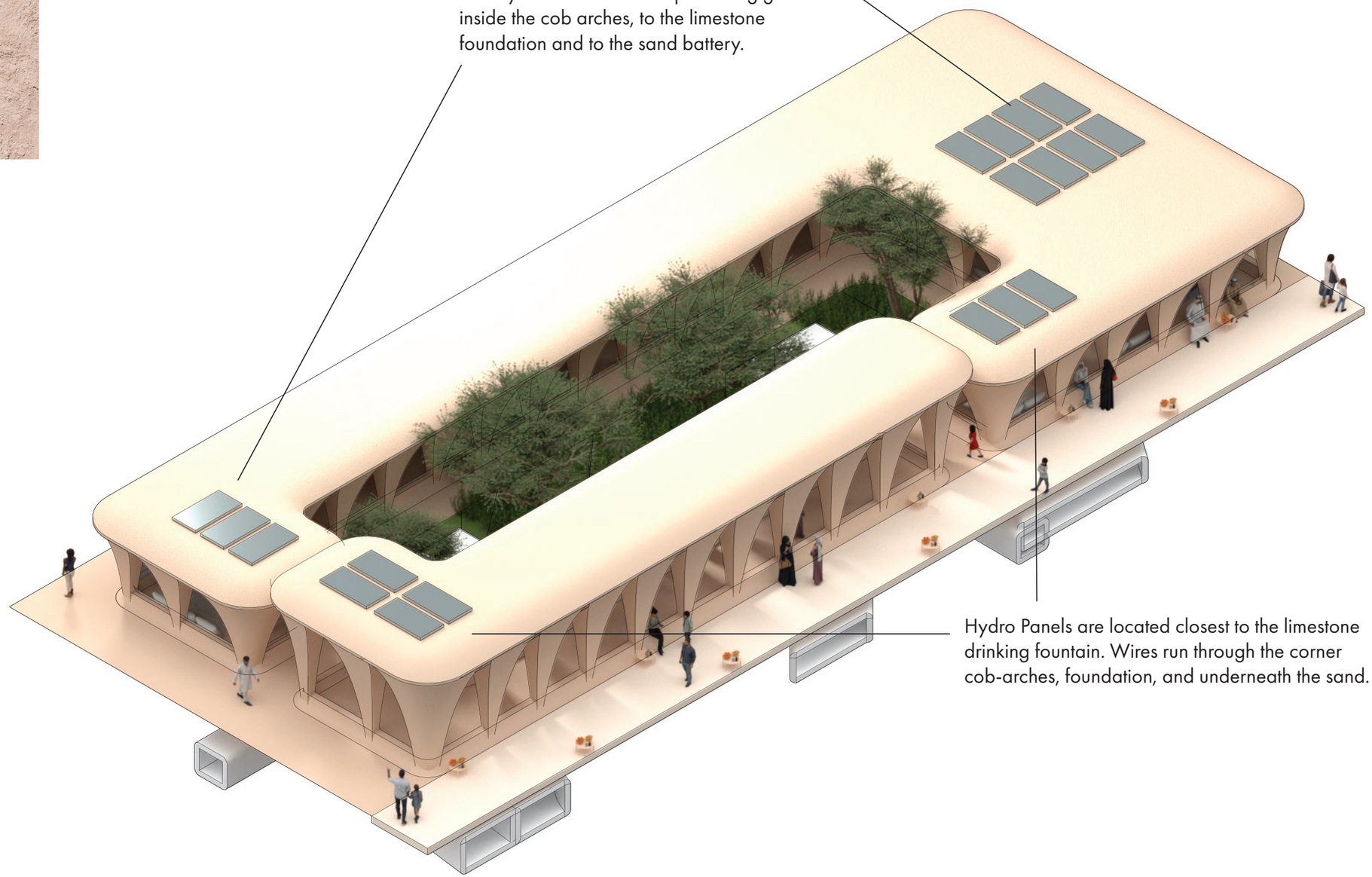
New Program - Lab





(Majlis) Social Spaces Components

Solar panels to provide electricity for daily use. Excess production goes directly to the sand battery underneath the majlis. Tubing goes inside the cob arches, to the limestone foundation and to the sand battery.



Hydro Panels are located closest to the limestone drinking fountain. Wires run through the corner cob-arches, foundation, and underneath the sand.

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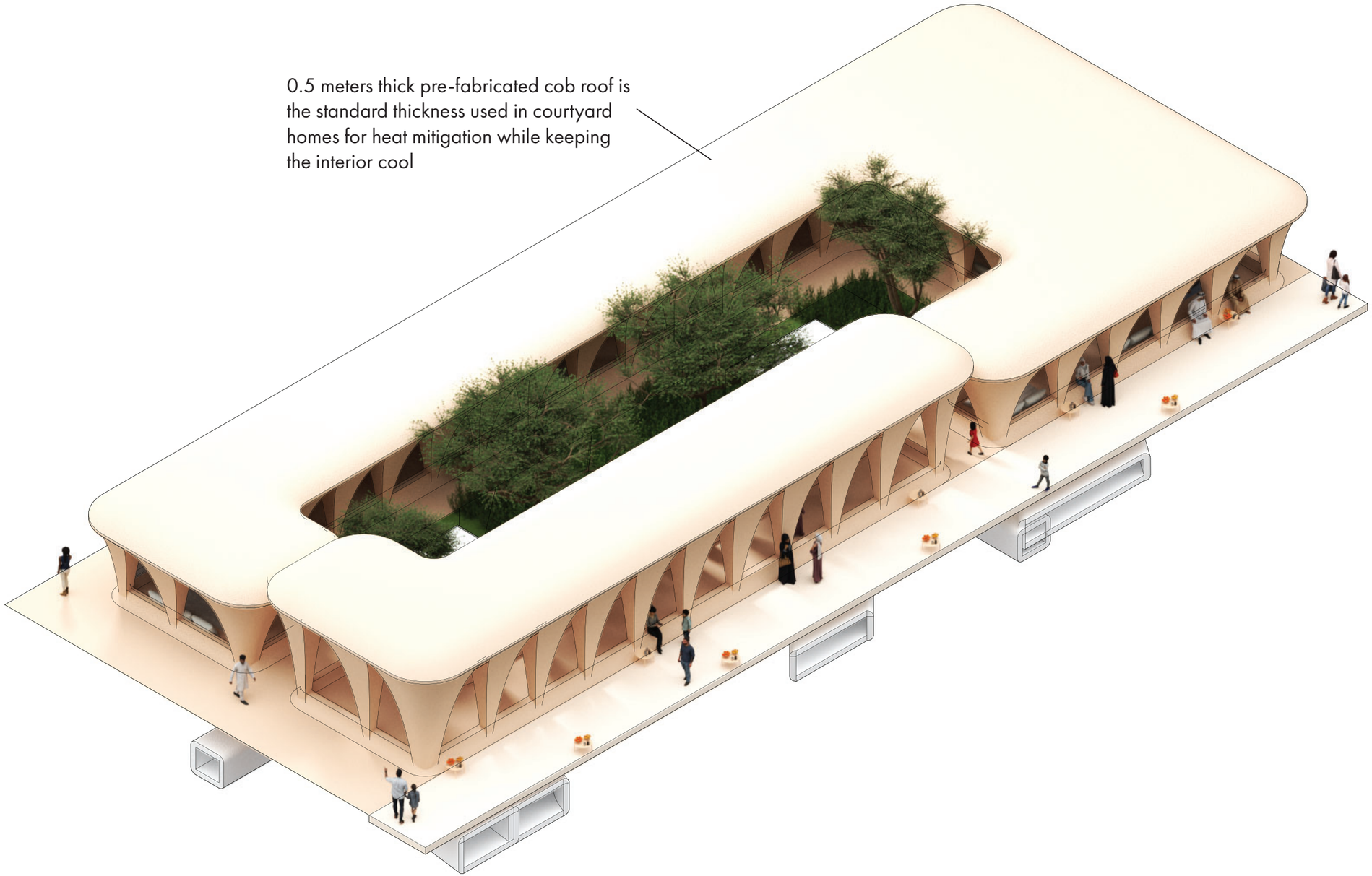
(Majlis) Social Spaces Components



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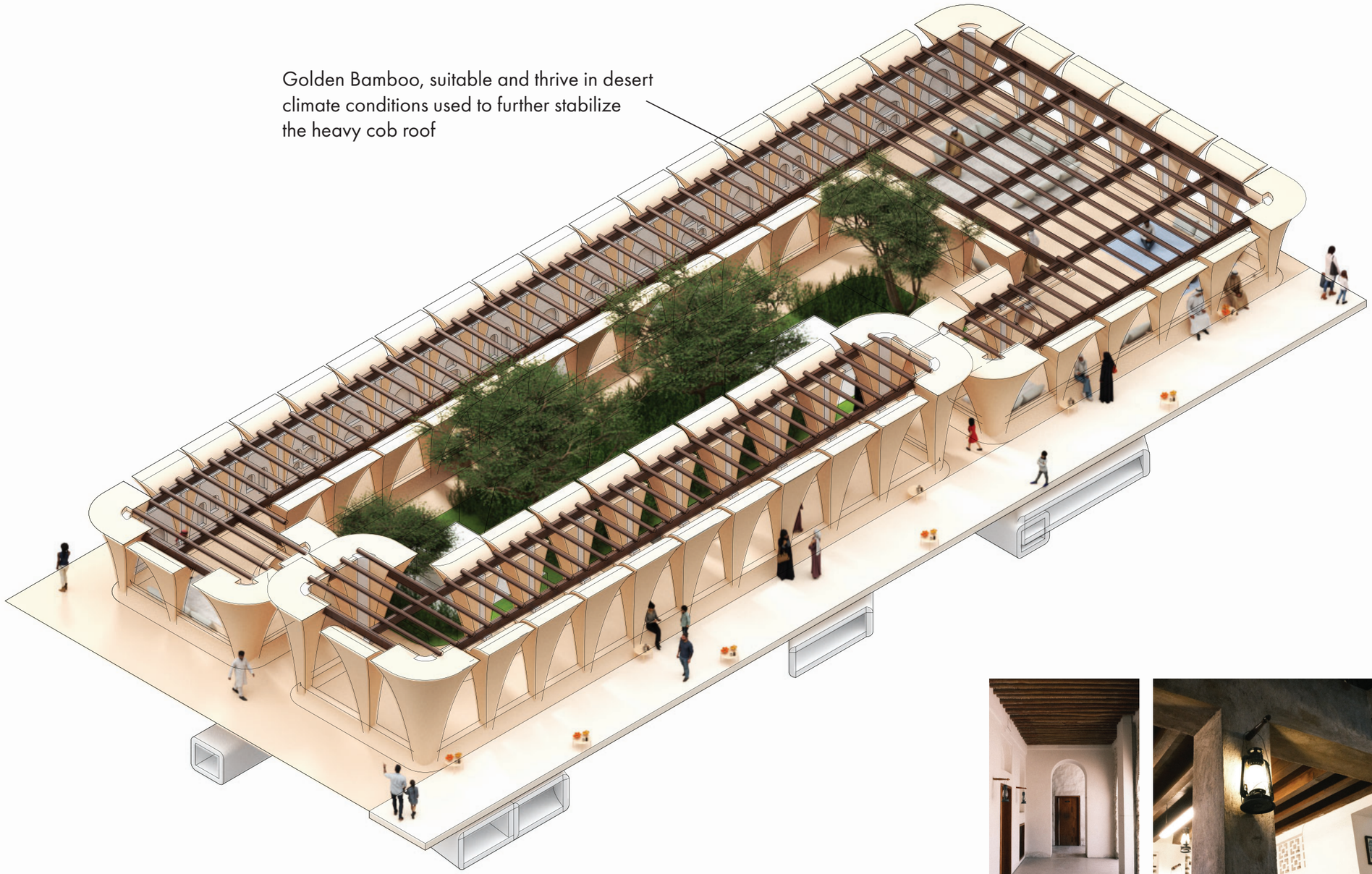
(Majlis) Social Spaces Components

Golden Bamboo, suitable and thrive in desert climate conditions used to further stabilize the heavy cob roof



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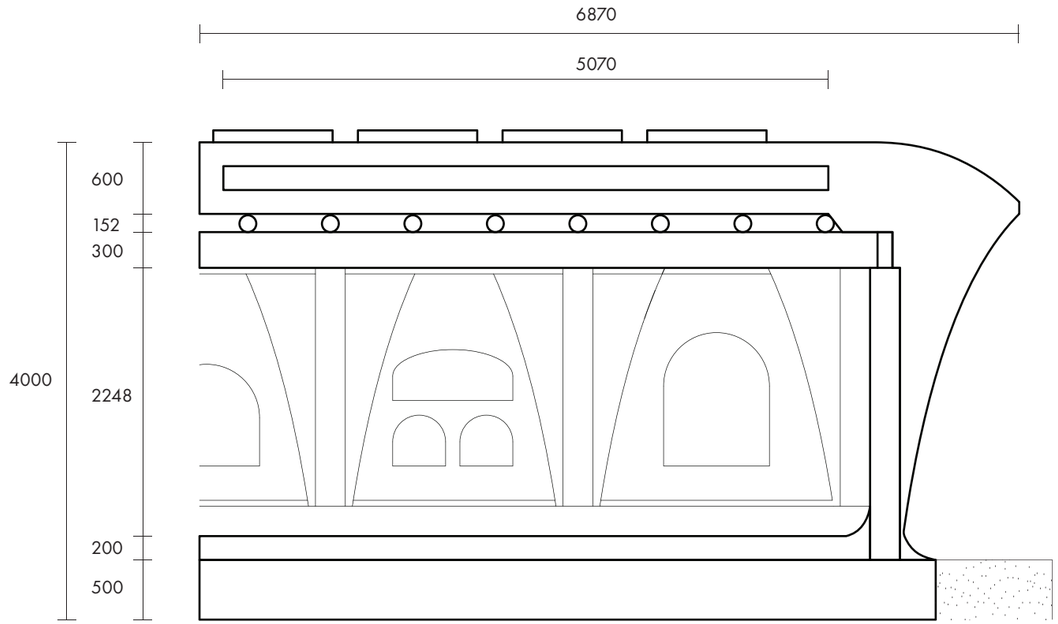
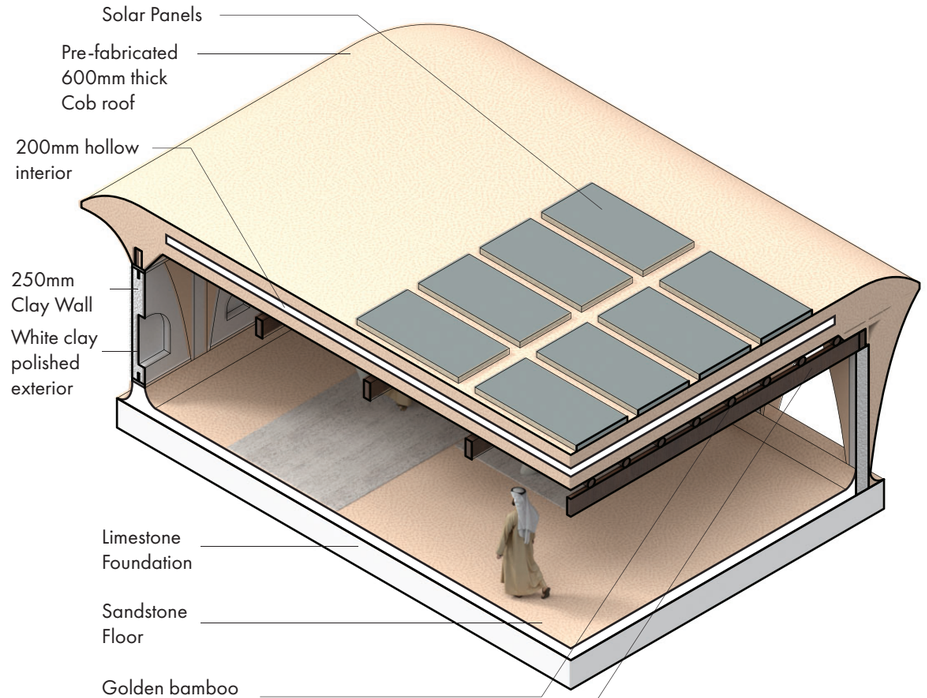
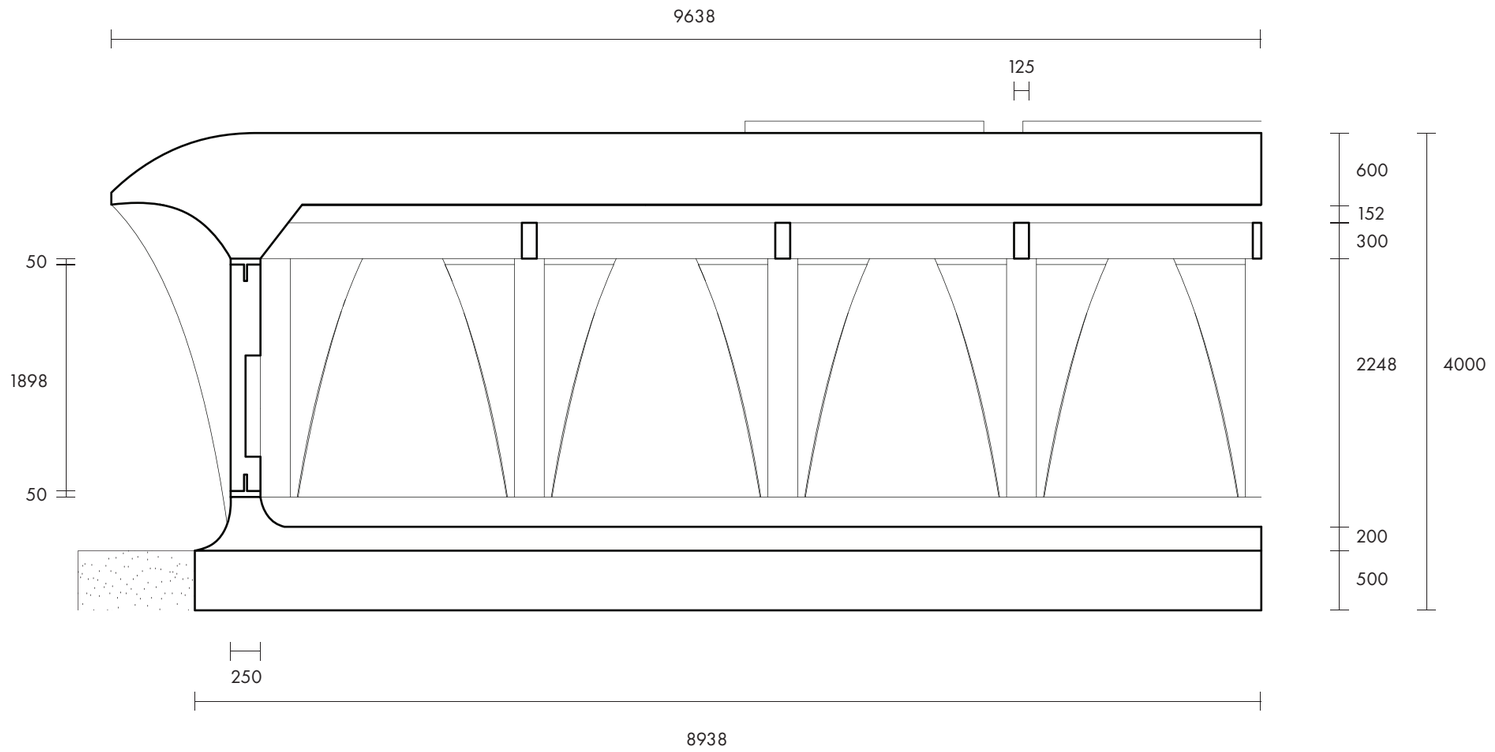
Majlis Section Details







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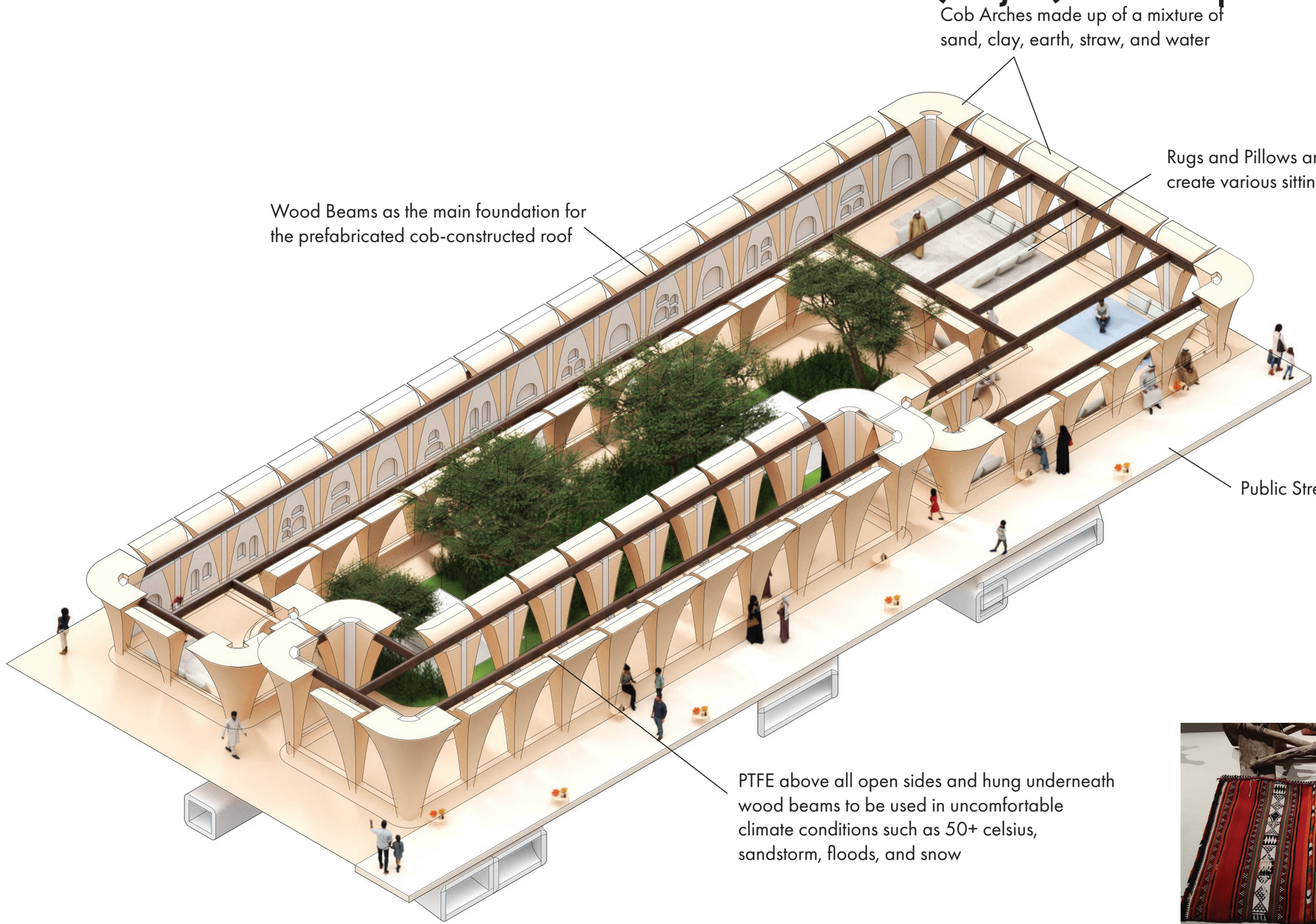
(Majlis) Social Spaces Components



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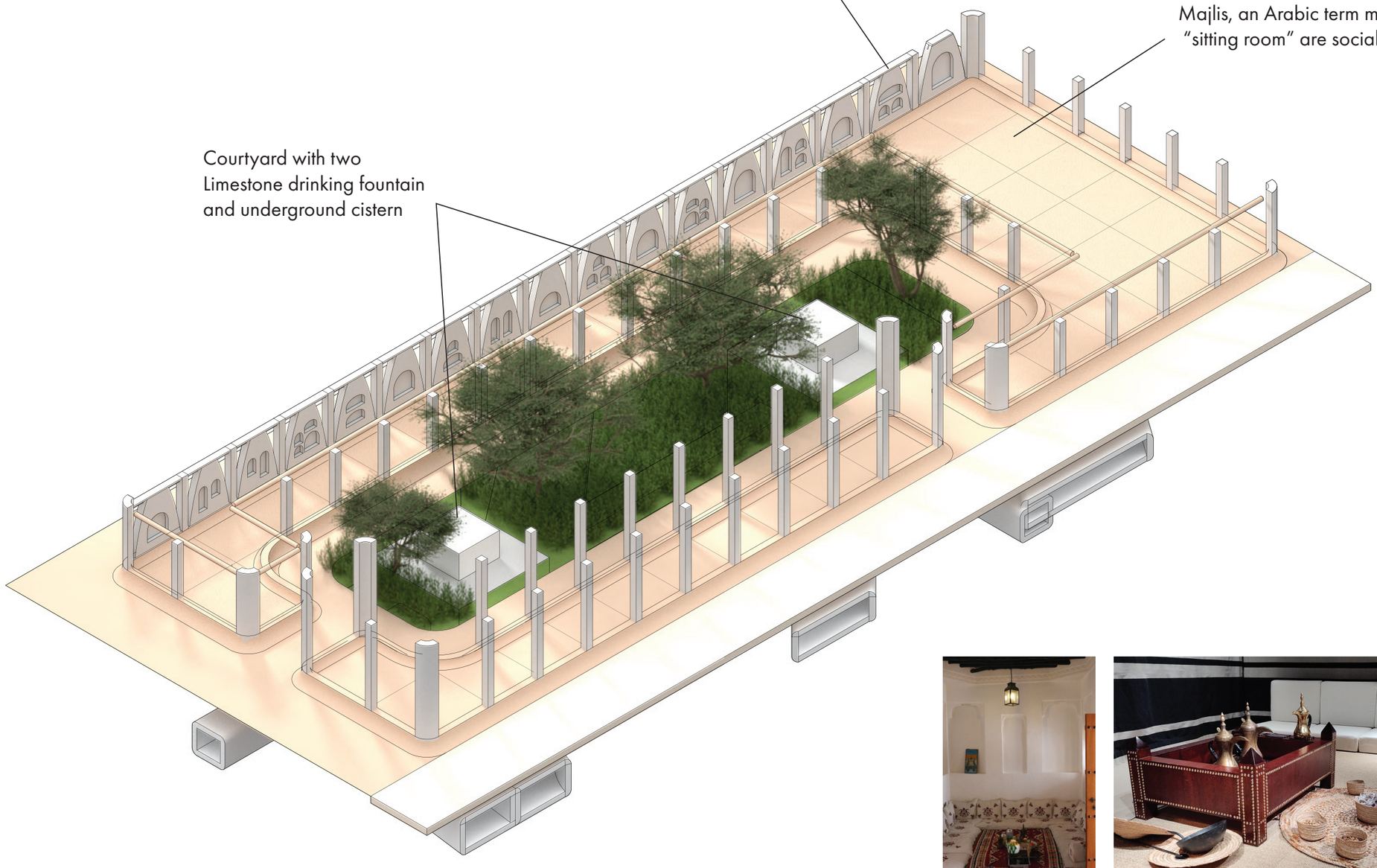
(Majlis) Social Spaces Components

0.25 meters thick clay wall for heat mitigation
and carved out shelves for storage

Majlis, an Arabic term meaning
"sitting room" are social gatherings

Courtyard with two
Limestone drinking fountain
and underground cistern



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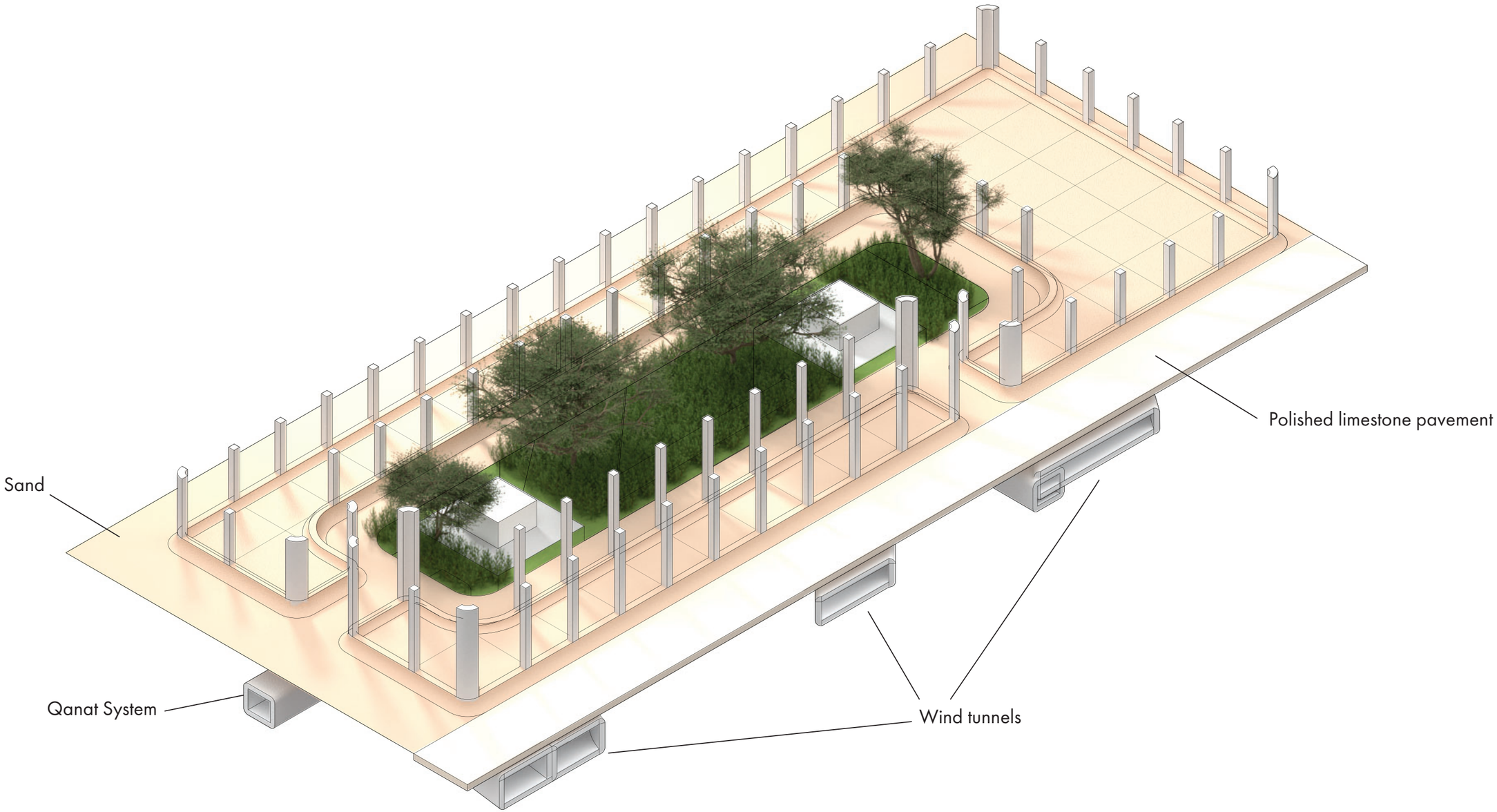
(Majlis) Social Spaces Components



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(Majlis) Social Spaces Components