

Green Sprout School

University Of Art | Tehran, Iran

Education Building (EB)



U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

CONTENTS

1. INTRODUCING THE TEAM

2. DESIGN GOALS

3. SOFTWARE

4. SITE CONTEXT

5. DECATHLON CONTESTS

5.1. Architecture

5.2. Engineering

5.3. Envelope

5.4. Efficiency

5.5. Grid-Interactivity

5.6. Life-Cycle

5.7. Health

5.8. Market

5.9. Community

ABOUT US



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Tehran University of art



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Assistant Professor at
Tehran University of art



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Architecture and Technology



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Architecture and Energy



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2nd year – M.Sc.
Architecture



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Architecture and Energy



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Graduated – M.Sc.
Solid State Physics

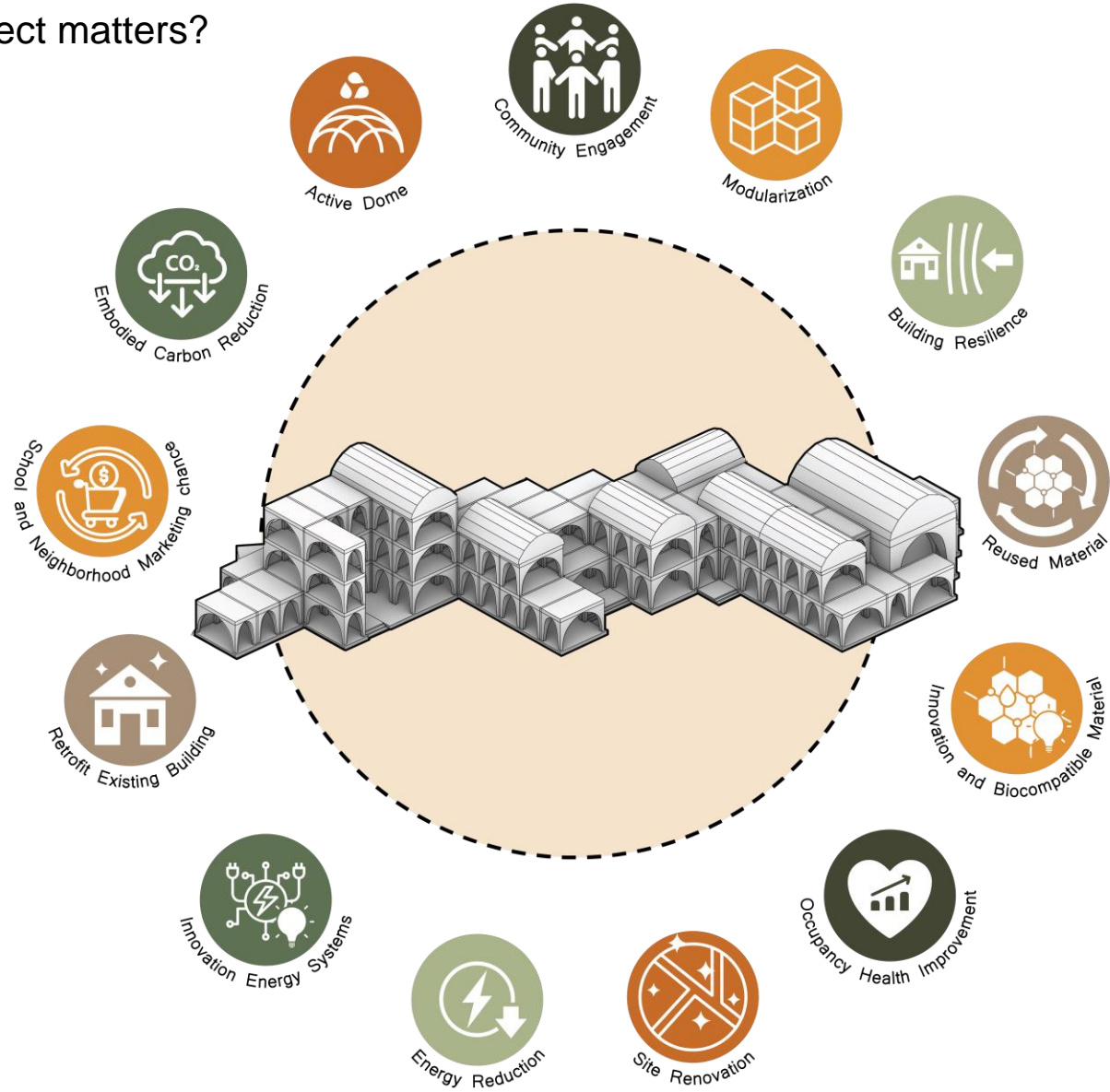



YEGANEH DEHROUYEH
Graphic Designer
Graduated - Bachelor
Architecture



Why our project matters?

- 1 --- Introducing the team
- 2 --- **Design goals**
- 3 --- Software
- 4 --- Site context
- 5 --- Project Highlights:
 - 5.1 --- Architecture
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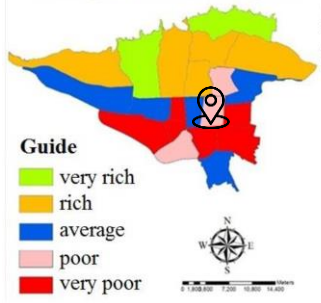
	REVIT		SAP2000
	RHINOCEROS		KARAMBA
	GRASSHOPPER		TRNSYS
	SKETCHUP		DESIGN BUILDER
	AUTOCAD		ORACLE CRYSTAL BALL
	LUMION		ODEON
	3D MAX		ONE CLICK LCA
	ILLUSTRATOR		CLIMATE STUDIO
	PHOTOSHOP		LADYBUG
	EXCEL		MATLAB

- 1 - - - - - Introducing the team
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Why did we choose this site?



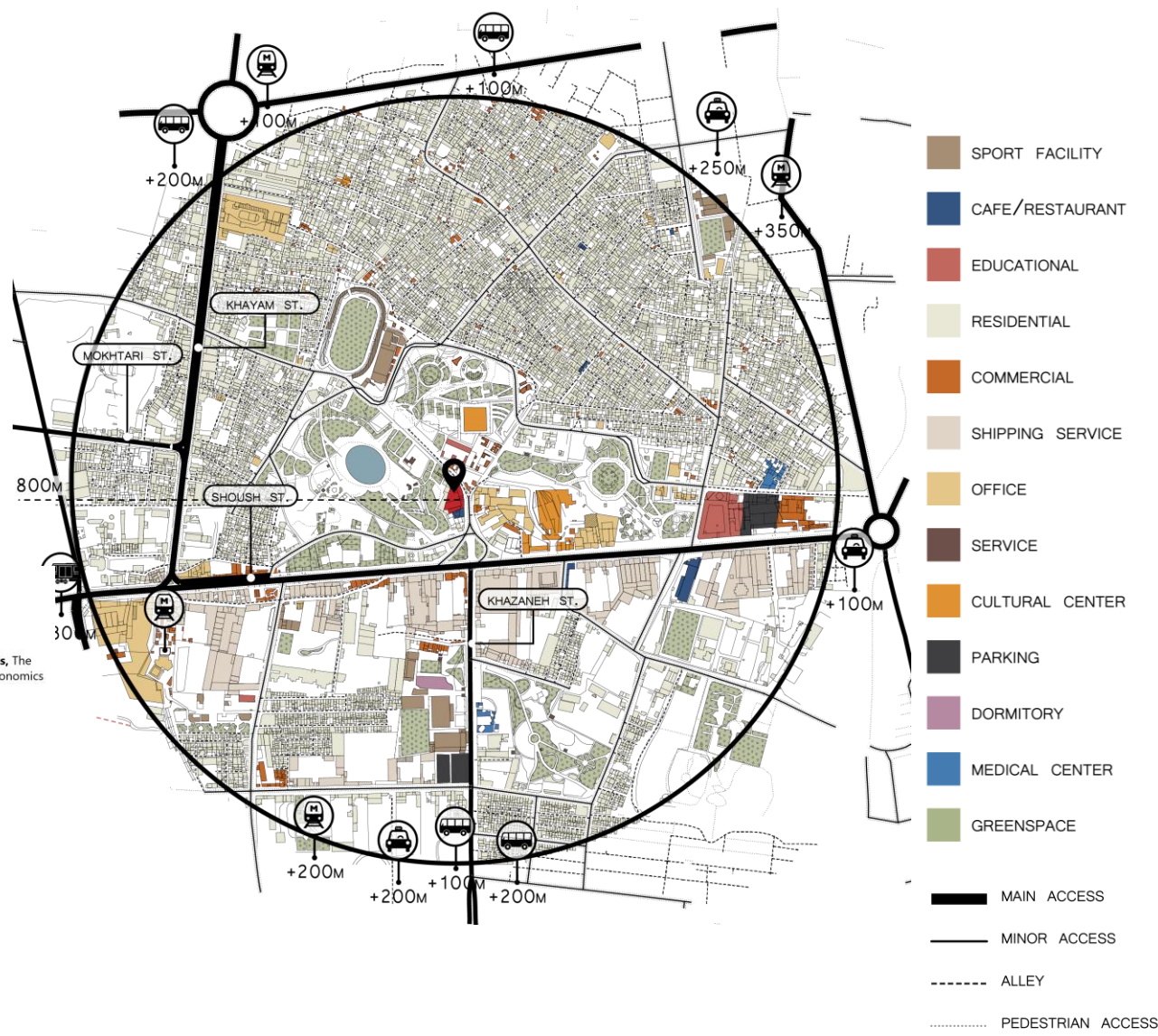
Spatial analysis of poor areas ranking in Tehran Metropolis



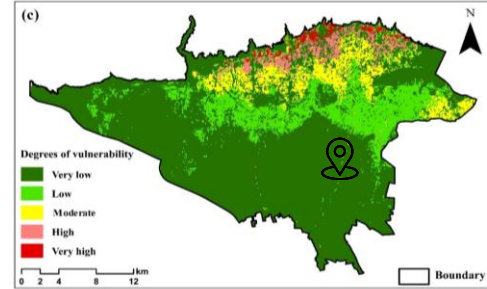
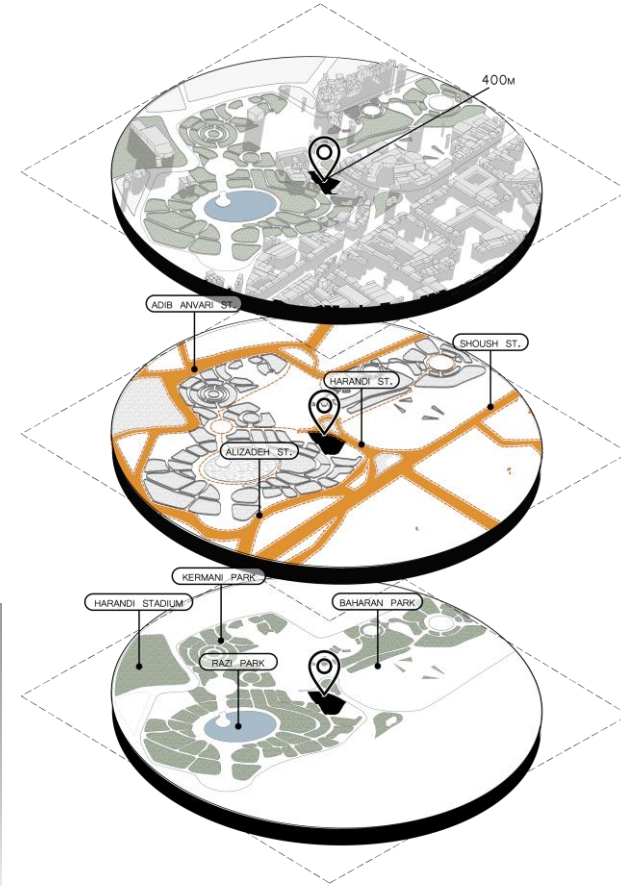
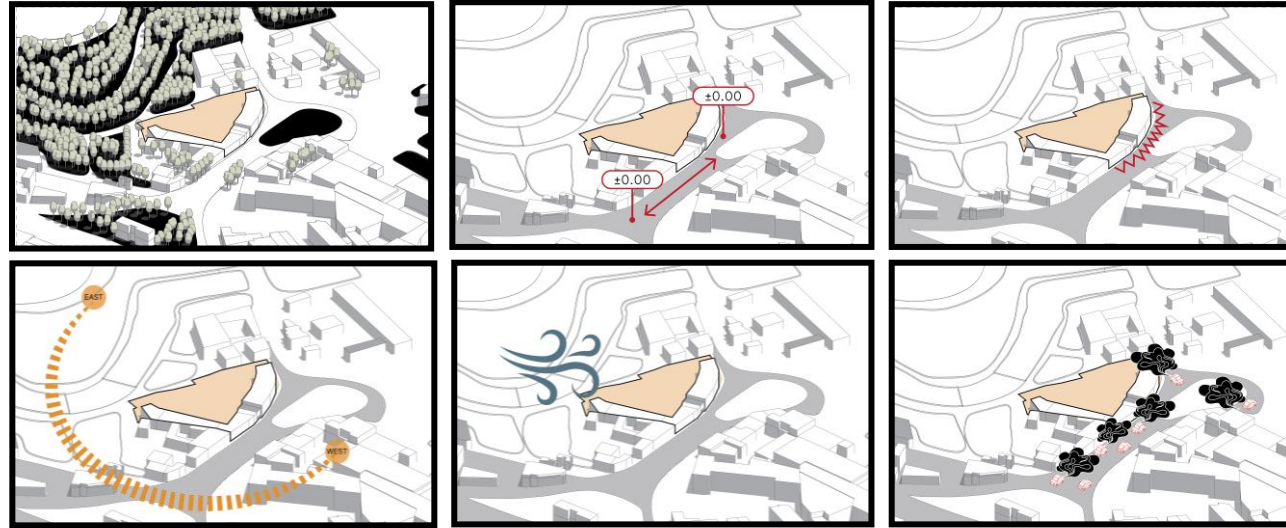
Movahhed A., Vali Noori S., Hataminejad H., Zanganeh A., Kamanroodi Kajouri M., *Spatial Analysis of Urban Poverty in Tehran Metropolis*, The Scientific-Research Quarterly Journal of Urban Economics and Management Vol. 4, No. 3(15), Summer 2016, Pages: 19- 36

Spatial analysis of poor areas ranking of Tehran Metropolis

Analysis of poor areas in Tehran



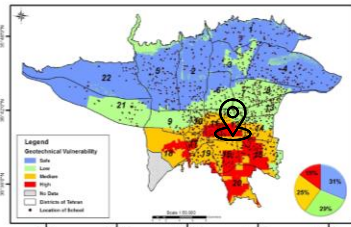
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International Journal of
Geo-Information

A Spatial Decision Support Approach for Flood Vulnerability Analysis in Urban Areas: A Case Study of Tehran
Rasoul Afari¹, Saman Nadizadeh Shorabeh¹, Mostafa Kouhnavard¹, Mehdi Homaei¹ and Jamal Jokar Arsanjani¹

ISPRS Int. J. Geo-Inf. 2022, 11, 380.
<https://doi.org/10.3390/ijgi11070380>



School distribution showing geotechnical vulnerability in Tehran city.

Seismic vulnerability assessment of school buildings in Tehran city based on AHP and GIS
Article in Natural Hazards and Earth System Sciences Discussions · September 2013
DOI: 10.5194/nhessd-1-4511-2013

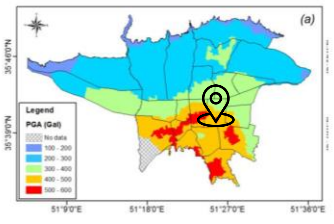
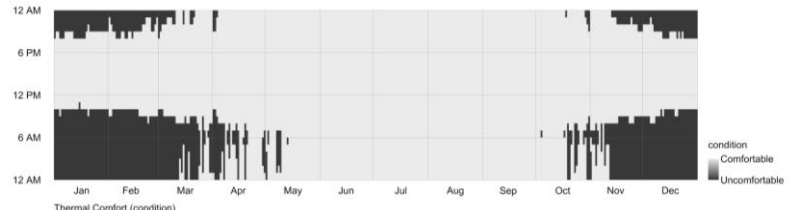


Fig. 3. (a) Distribution of PGA for the Rey fault scenario peak ground acceleration (PGA)

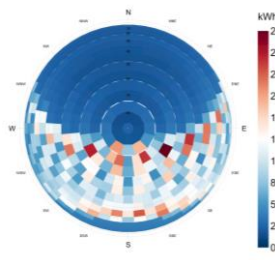


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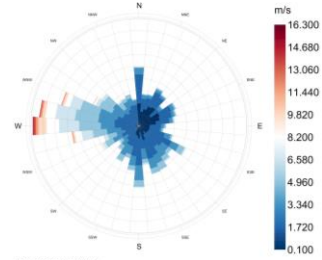
Site's Climate Zone:2B



Hours of Comfort

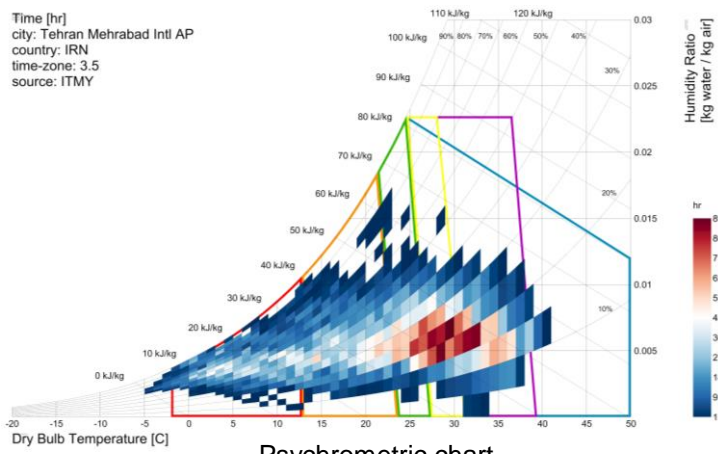


Total Radiation

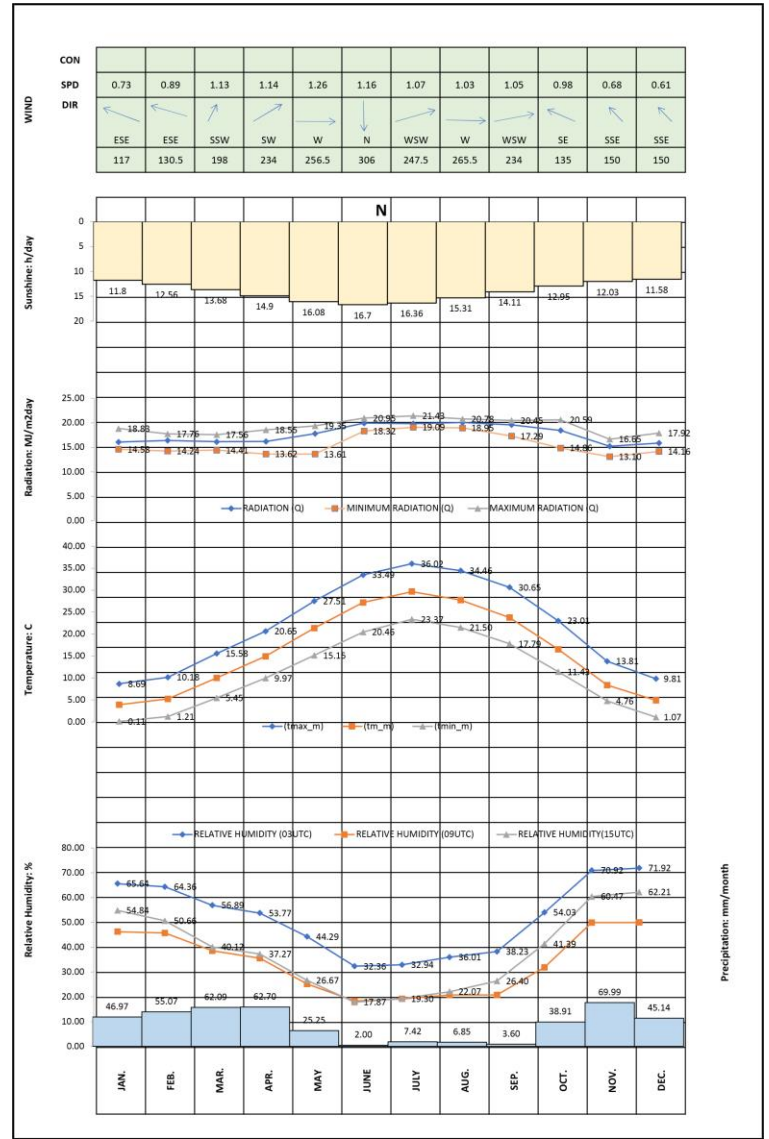


Wind Speed (m/s)
city: Tehran Mehrabad Intl AP
country: IRN
time-zone: 3.5
source: ITMY
period: 1/1 to 12/31 between 0 and 23 @1
Calm for 22.91% of the time = 2007 hours.
Each closed polyline shows frequency of 0.7% = 50 hours.

Annual wind rose



Psychrometric chart



Composite Climate graph

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Inhabitants:



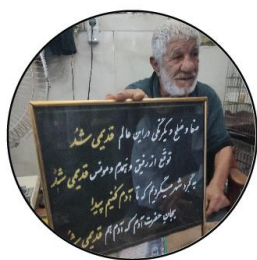
Shop Owner:

Installing fences around the park restricted public access to the shops in the design area, leading to economic stagnation for those businesses. The park's secluded nature at night has attracted criminals, increasing crime rates and compromised security. Neglecting the maintenance of the shops' original texture has led to their deterioration. The lack of employment opportunities for the youth in this area has led to a rise in delinquency and crime. Additionally, the presence of a poorly designed and uncontrolled large park filled with drug addicts has made the area unsafe at night, contributing to the increase in criminal activity. Unfortunately, This park has become a hotspot for young people and neighborhood residents to engage in criminal behavior.



Shop Worker:

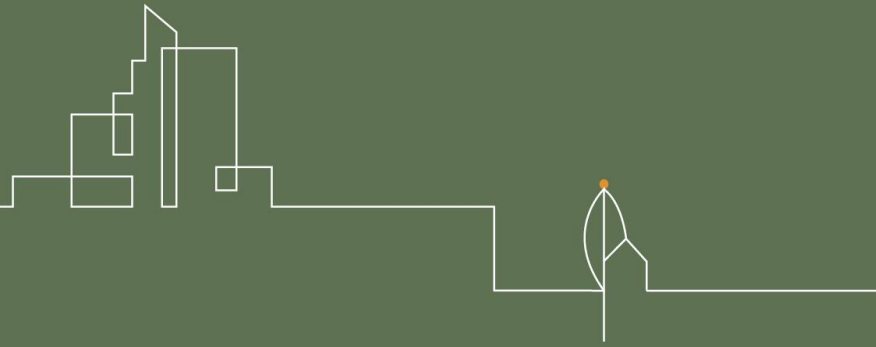
The environment and atmosphere of this area is only for men and it has a masculine environment where only men can travel and there is no suitable atmosphere and space for women's activities and their movement. Even the restaurants and cafes in this area are male-dominated and families are reluctant to visit there.



Shop Owner:

The families and people of this neighborhood are among the lowest-income strata of Tehran, which has forced their children to work from an early age to help the family and earn. Mainly because this neighborhood is full of crime, they are attracted to illegal activities and delinquency. Young people should learn arts or crafts so that they don't have to commit crimes.

5.1




Architecture



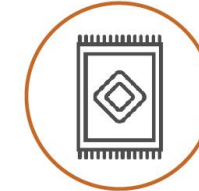
Why did we **choose** these **arts** for the school?

Revival of ancient culture and art in the young generation

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Pottery




Carpet Weaving



Fabric Design & Sewing

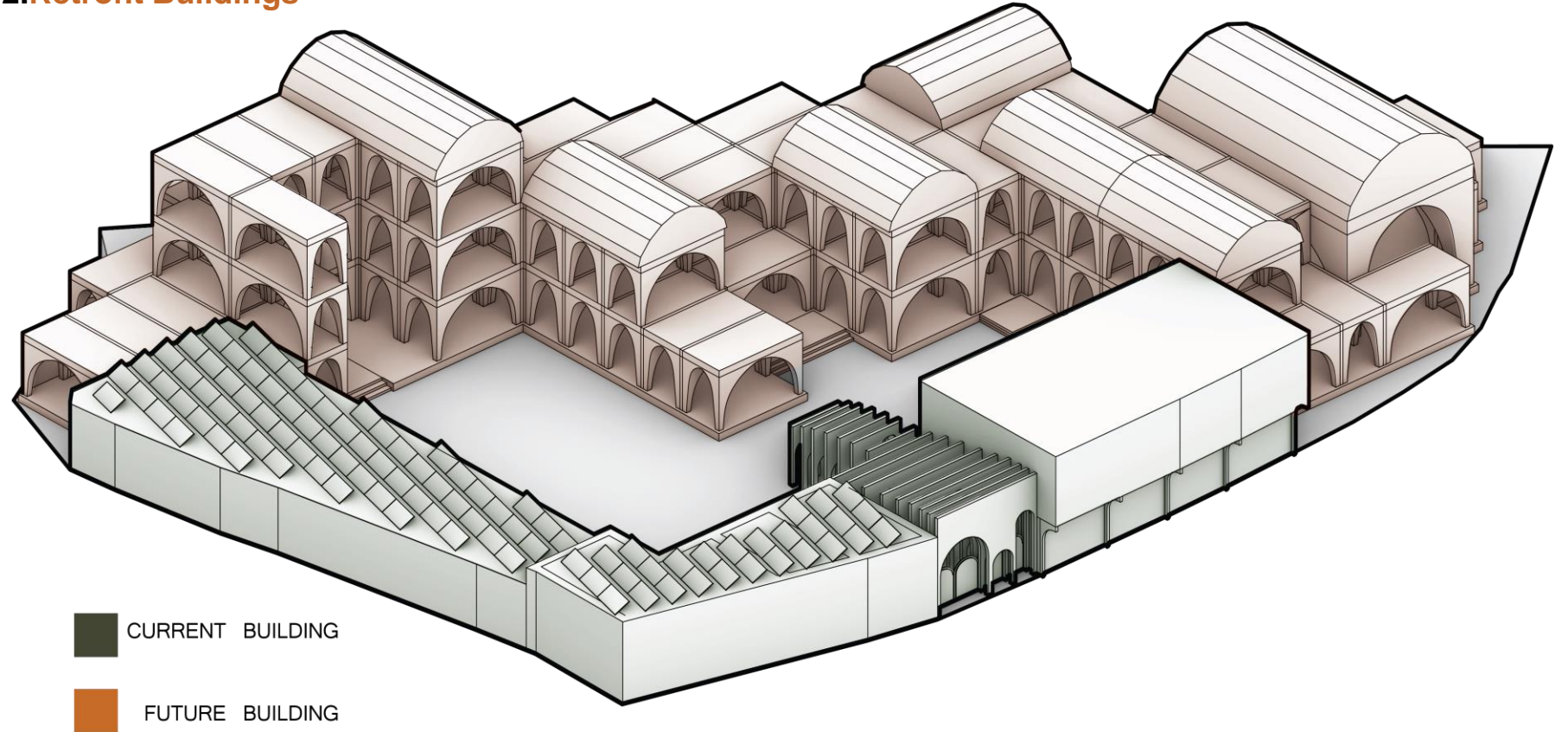


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Our design stage divides into **two parts**:

1. New Buildings Design

2. Retrofit Buildings

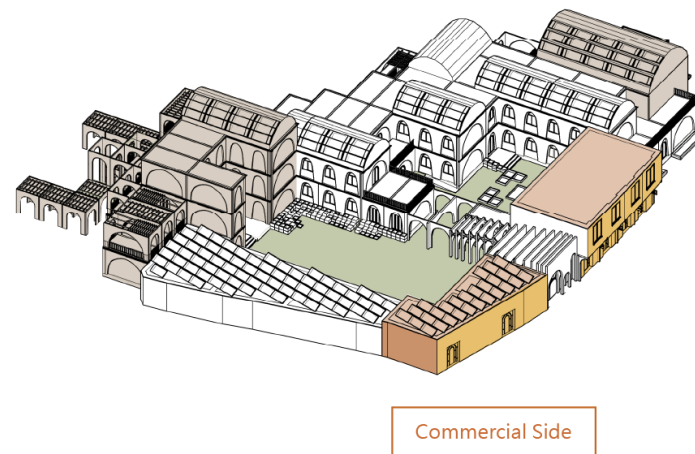
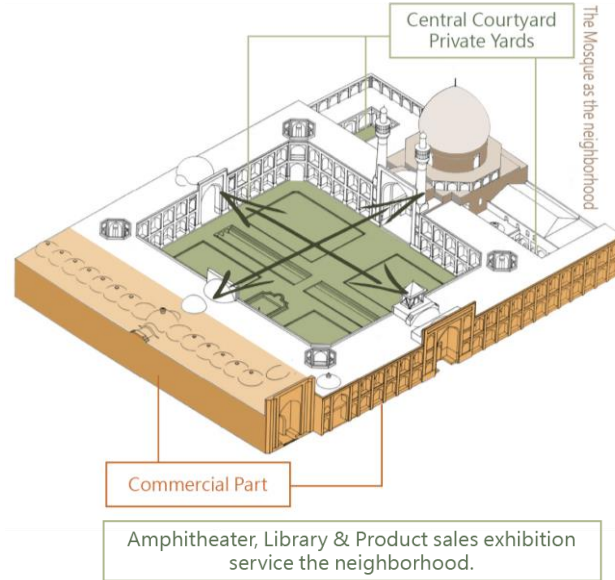




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New Building Design Process:

Be inspired by the model of traditional Iranian **four-porch** schools

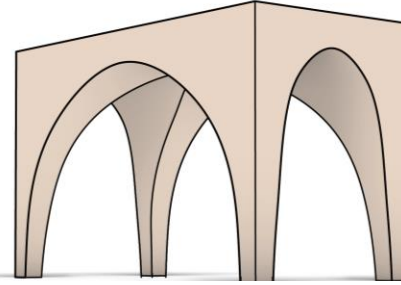




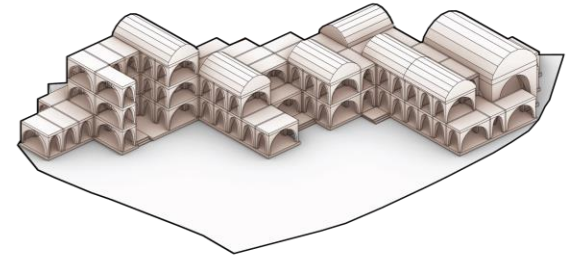
New building concept design :




ChaharTaqi
having four arches



Architecture



The project consists of modules

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- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
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1

Introducing the team

2

Design goals

3

Software

4

Site context

5

Project Highlights:

5.1



Architecture

5.2

Engineering

5.3

Envelope

5.4

Efficiency

5.5

Grid-Interactivity

5.6

Life-Cycle

5.7

Health

5.8

Market

5.9

Community

Retrofit Process:

Existing:



Retrofitting:





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- 3 - - - - - Software
- 4 - - - - - Site context
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Space Types:
Physical Program:

Activity	Space	no.	Floor	Area m ²	
	Classrooms	6	⓪/①	282	
	Flexible Classrooms	2	⓪/①	94	
	Workshops	3	⓪	214	590m²
Administrative	Offices	9	⓪/①	159	159m²
	Multifunctional Spaces	1	⓪	160	
	Book Room	1	①	46	
	Library	1	②	110	316m²
	Bakery	1	⓪	33	
	Pottery Shop	1	⓪	29	
	Stationary Shop	1	⓪	29	
	Fabric Shop	1	⓪	31	
	Supermarket	1	⓪	20	
	Persian Restaurant	1	⓪	52	
	Students Products Shops	2	⓪	52	
	Book Cafe	1	①	144	390m²
	Facilities	1	⓪	111	
	Janitor	1	⓪	24	
	Buffet	1	⓪	63	
	Prayer Room	1	①	48	
	Storage	1	⓪	15	
	Waste Disposal	1	⓪	14	
	Air Condotioning Room	1	⓪	15	290m²



New design plan (Ground Floor) :

- 1 - Introducing the team
- 2 - Design goals
- 3 - Software
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 - 5.1 Architecture
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SANSSEVERIA



WEEPING FIG



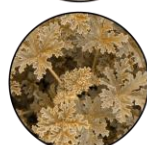
POTHOS



LAVENDER



GERANIUM



DAVANA



MYCELIIUM

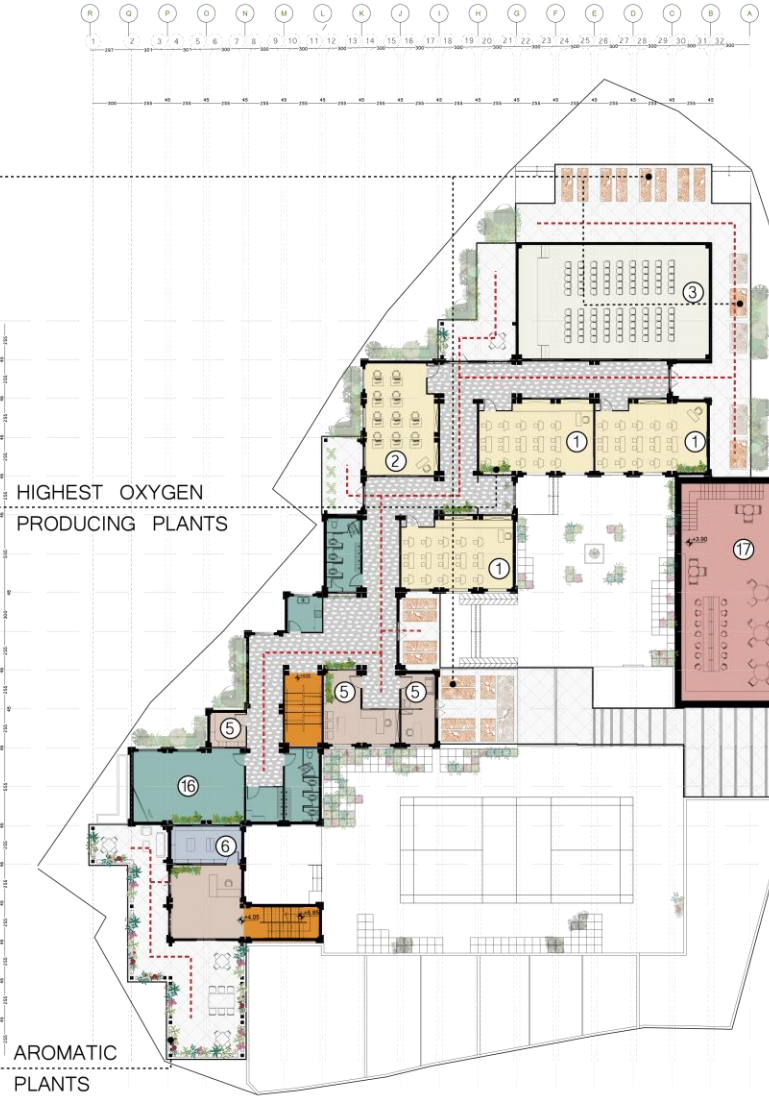


- 1 CLASSROOM
- 2 FLEXIBLE CLASSROOM
- 3 MULTIPURPOSE HALL
- 4 MECHANICAL
- 5 WORKSHOP
- 6 BAKERY
- 7 POTTERY SHOP
- 8 STATIONARY SHOP
- 9 HEBERDASHERY
- 10 JANITOR ROOM
- 11 SUPER MARKET
- 12 PERSIAN RESTAURANT
- 13 BUFFET
- 14 STUDENTS PRODUCT SHOP
- 15 OFFICE
- 16 PRAYER ROOM
- 17 BOOK CAFE
- 18 STORAGE
- 19 WASTE MANAGEMENT ROOM
- 20 LIBRARY



New design plan (First Floor) :

- 1 - Introducing the team
- 2 - Design goals
- 3 - Software
- 4 - Site context
- 5 - Project Highlights:
 - 5.1 Architecture
 - 5.2 - Engineering
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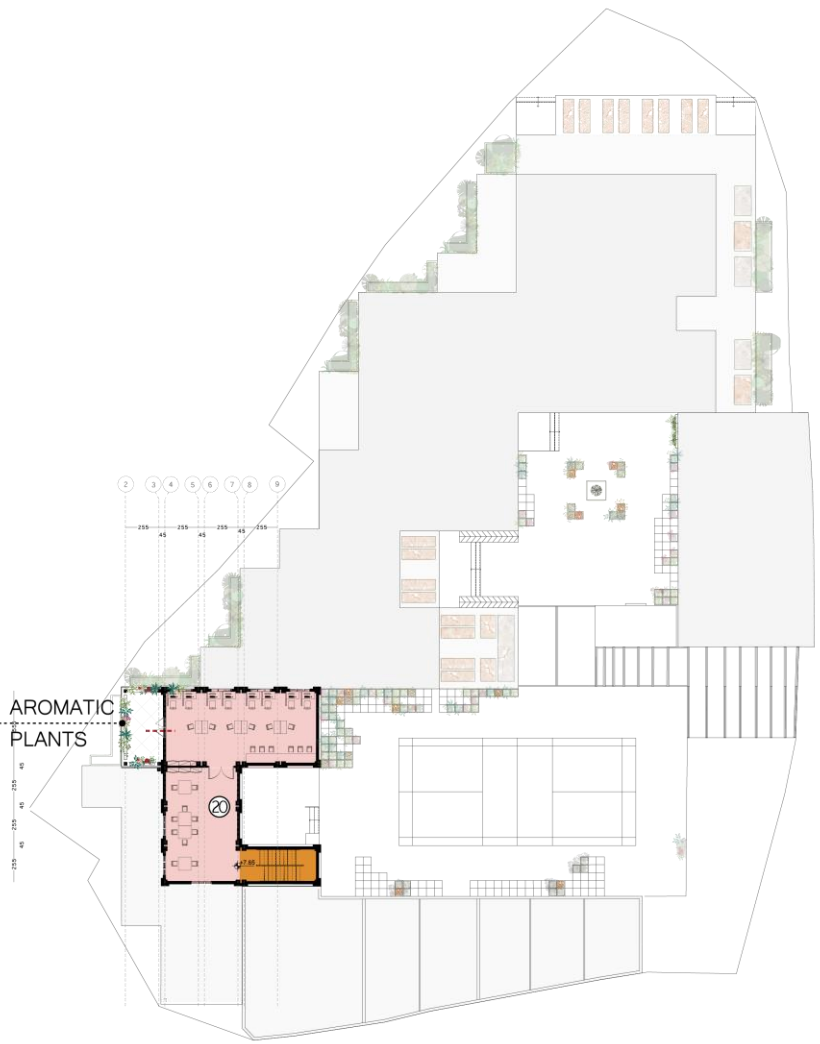


New design plan (Second Floor) :

- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
 - 5.1 **Architecture**
 - 5.2 - - - - - Engineering
 - 5.3 - - - - - Envelope
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AROMATIC PLANTS

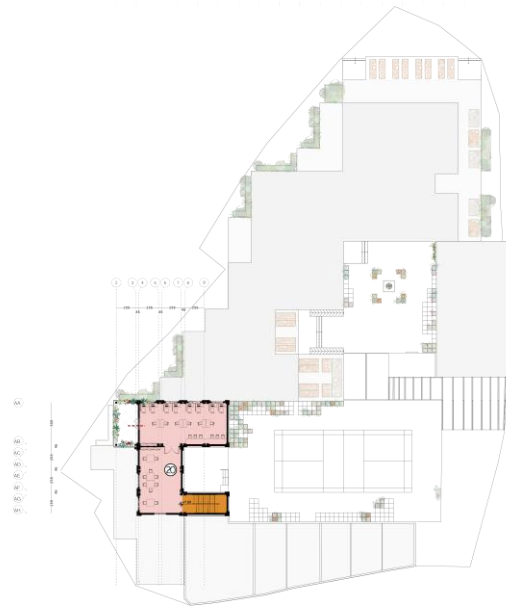
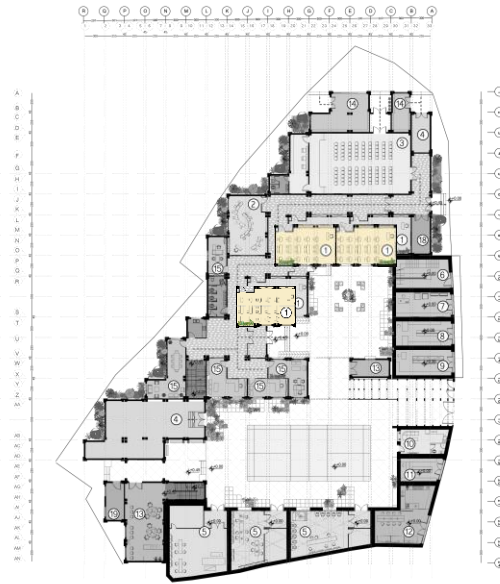


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Newly Designed Buildings:



Classrooms:



Library:



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Retrofitted Buildings:



Retrofitting the old Men's Coffee House to a Persian restaurant : A place for the **Whole** family (Men and Women)



Retrofitting the old stores into a Book Cafe: A place for increasing **public awareness**





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Retrofitted Buildings:




Conversion of southern buildings into **workshops** with structural **reinforcement**:



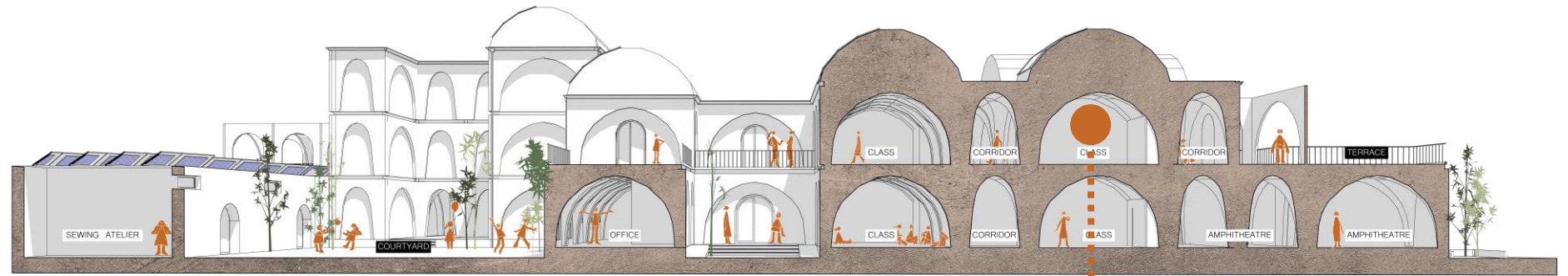
Conversion of storage area near school entrance into a **Bakery and a café**:



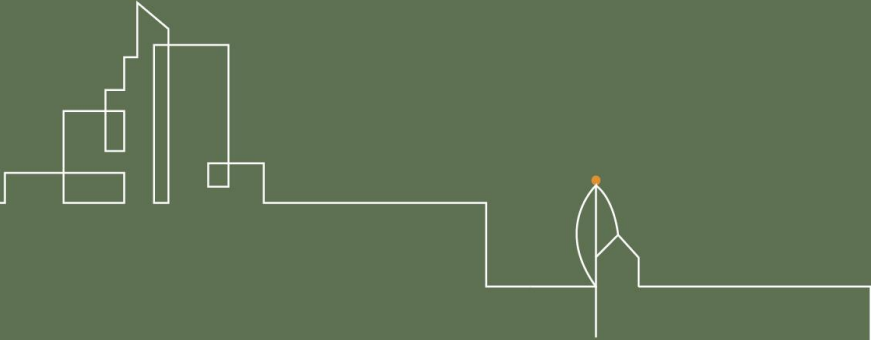


- 1 - - - - - Introducing the team
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Architectural Section:



5.2



Engineering

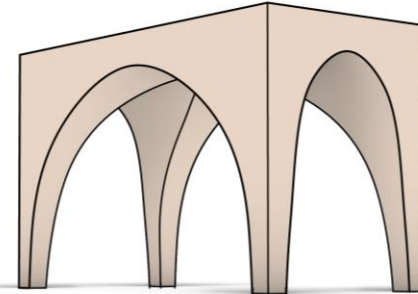


How did we make the **structure modular**?

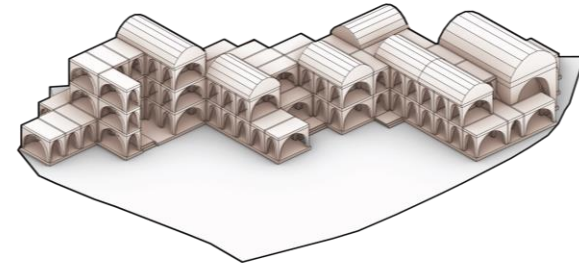
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 - 5.1 - - - - - Architecture
 - 5.2 - - - - - **Engineering**
 - 5.3 - - - - - Envelope
 - 5.4 - - - - - Efficiency
 - 5.5 - - - - - Grid-Interactivity
 - 5.6 - - - - - Life-Cycle
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 - 5.9 - - - - - Community



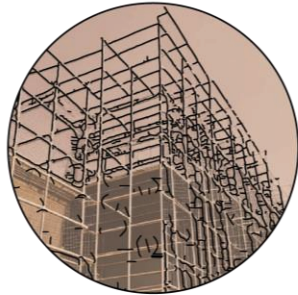
ChaharTaqi
having four arches



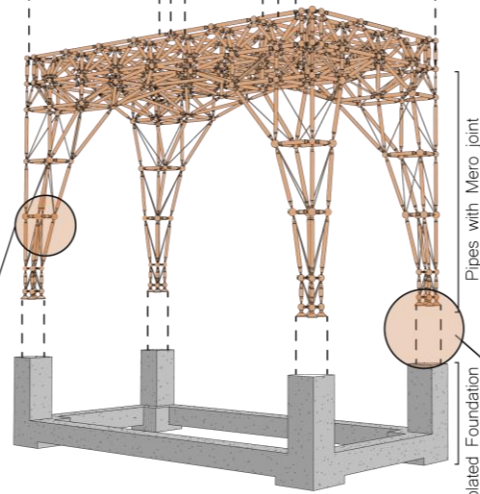
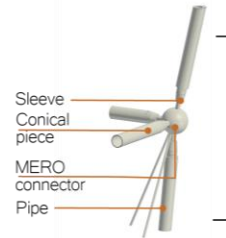
Architecture



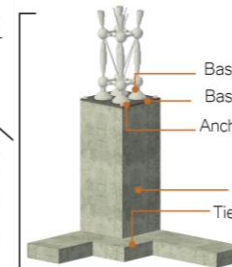
The project consists of modules



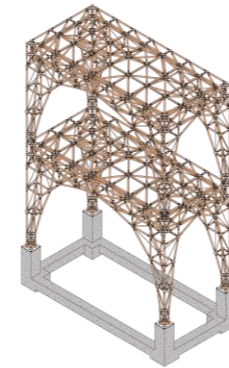
Reused Structure
using scaffolding pipes



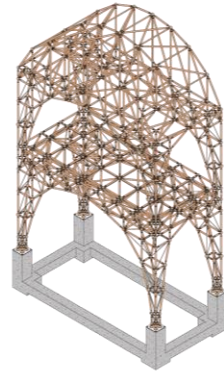
Structure



Isolated Foundation



A
Module with flat roof

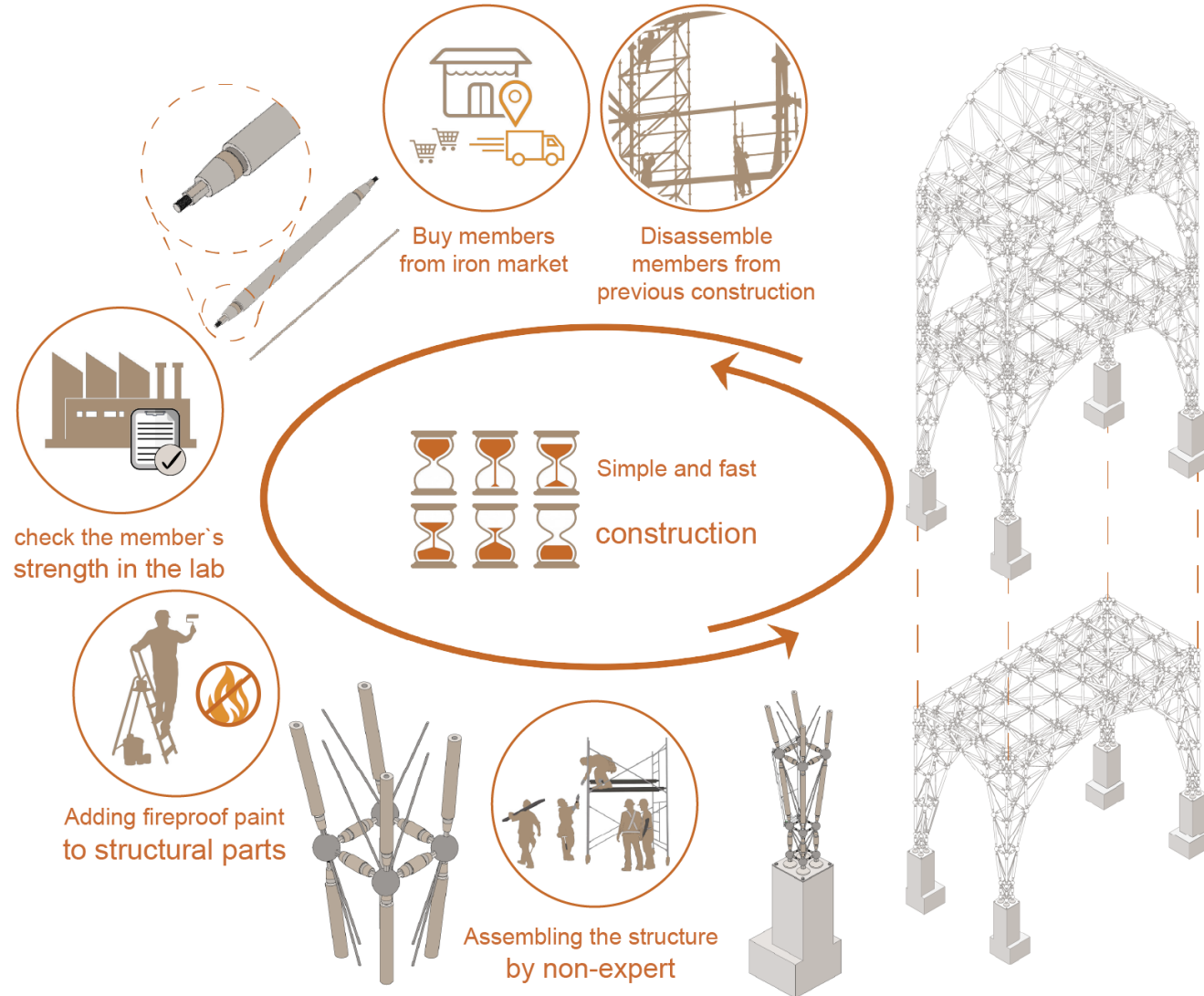


B
Module with arched roof




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 - 5.2 - - - - - **Engineering**
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 - 5.6 - - - - - Life-Cycle
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 - 5.8 - - - - - Market
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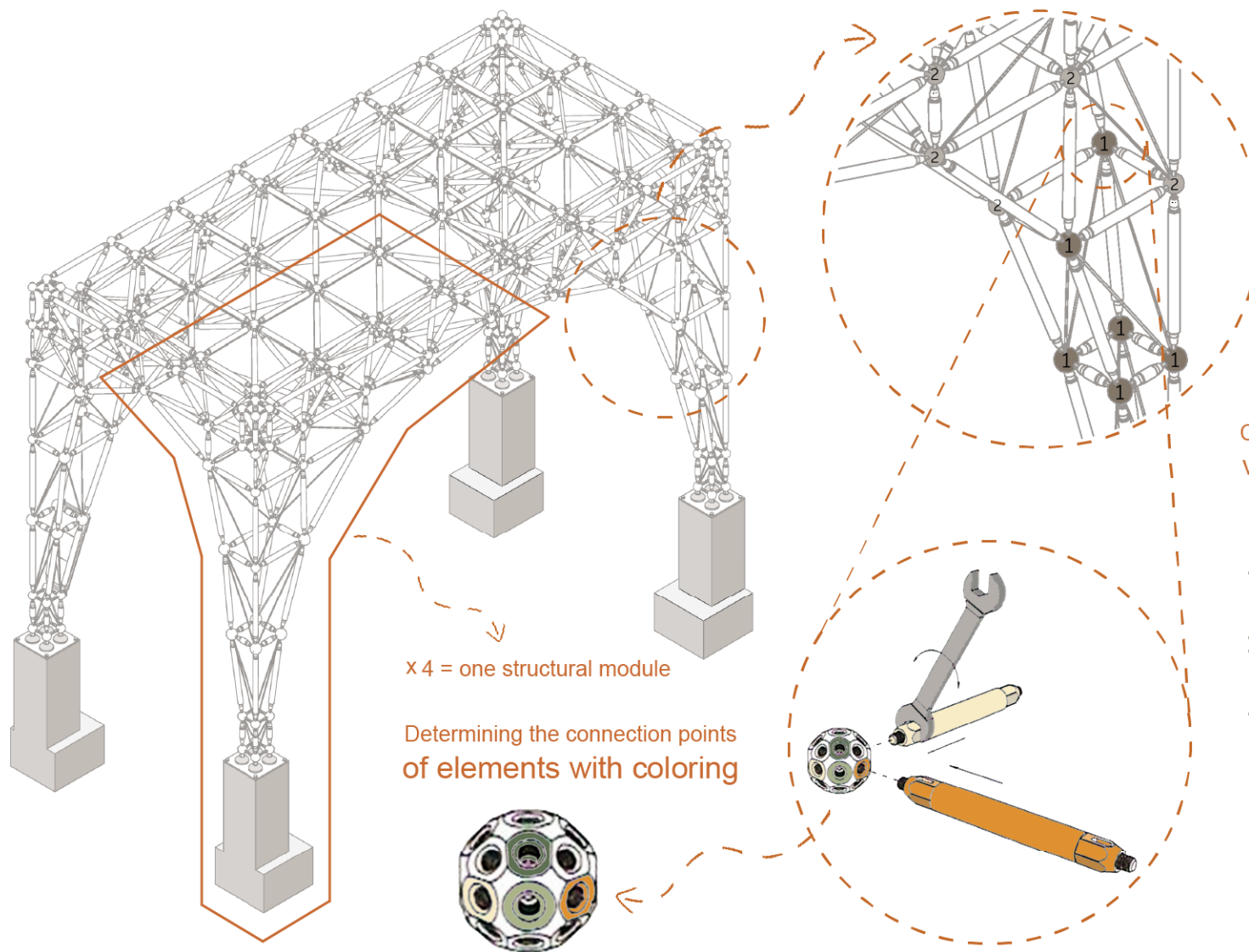
Why did we use **second-hand scaffold pipes** as the **structural systems**?





Why does our structure module have simple construction?

- 1 --- Introducing the team
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Categorizing mero's with numbering



Simple and fast construction



- 1 - - - - -
- 2 - - - - -
- 3 - - - - -
- 4 - - - - -
- 5 - - - - -
- 5.1 - - - - -
- 5.2 - - - - -
- 5.3 - - - - -
- 5.4 - - - - -
- 5.5 - - - - -
- 5.6 - - - - -
- 5.7 - - - - -
- 5.8 - - - - -
- 5.9 - - - - -

Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

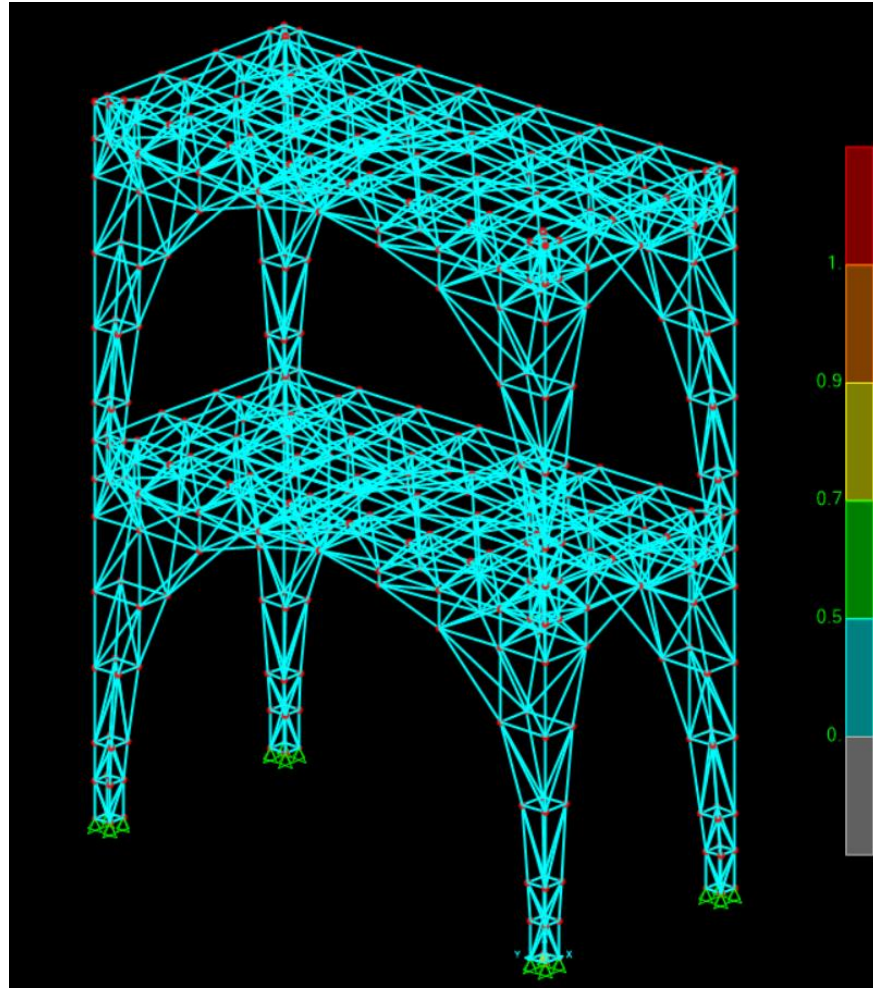
Life-Cycle

Health

Market

Community

How did we check the **structure's durability** against **earthquakes**?



Element ratio

Stability and degree of static indeterminacy

The DSI formula for pin jointed space frame: $DSI = m + r - 3j$

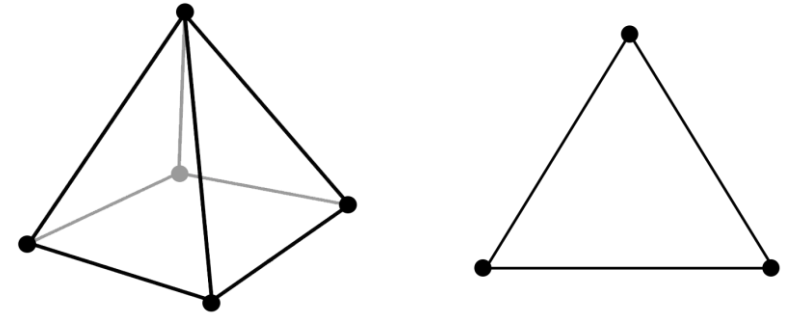
m: members *r*: support reactions *j*: joints

- DSI < 0 UNSTABLE
- DSI = 0 DETERMINATE
- DSI > 0 INDETERMINATE

DSI for the structural module:

$$m + r - 3(j) = DSI$$

$$776 + 48 - 3(225) = 149 \quad \text{INDETERMINATE}$$

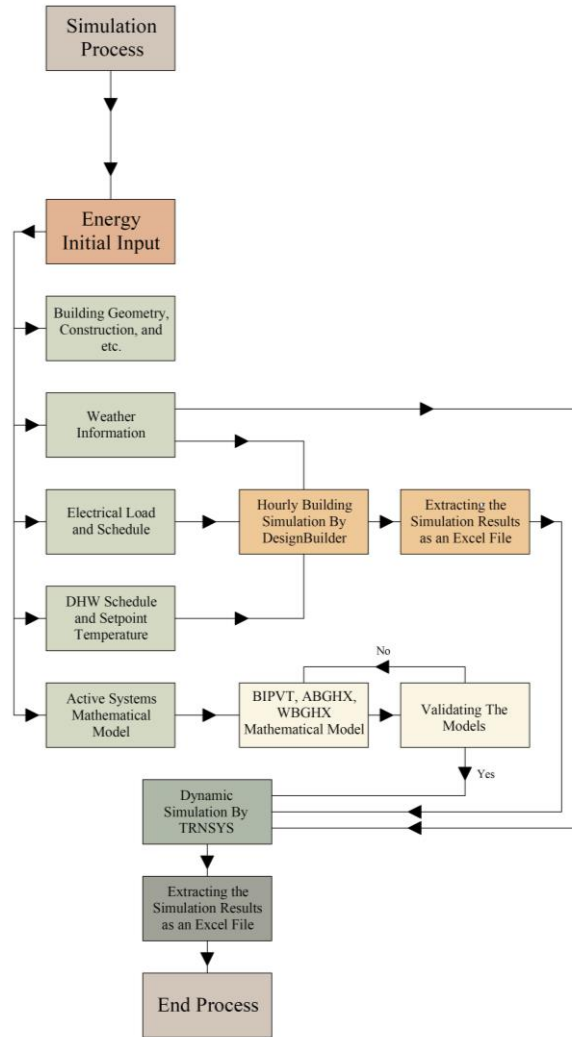


The smallest repeating components(Square pyramid and Triangle) that make up the structural module have **geometric stability**

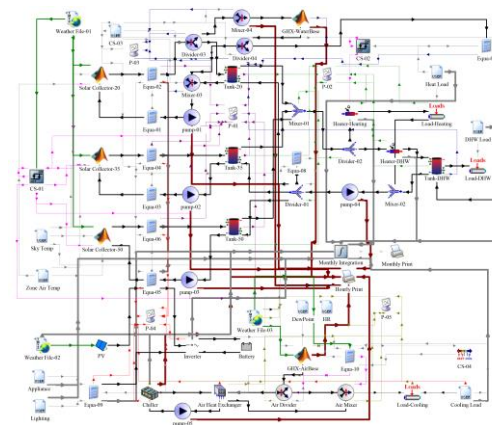
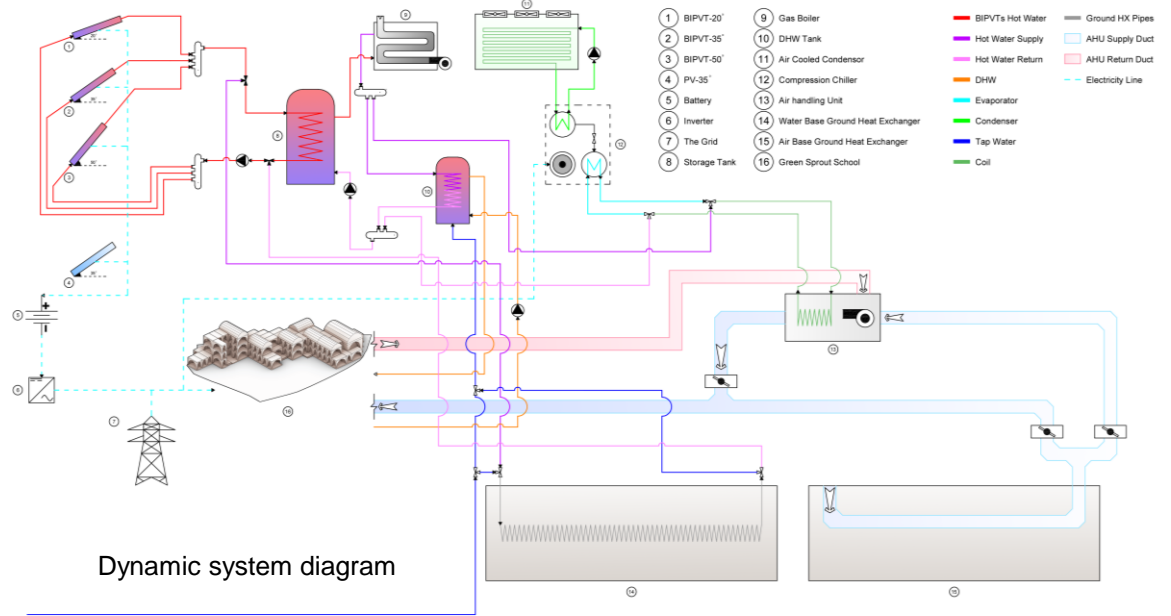


- 1 - Introducing the team
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 - 5.8 - Market
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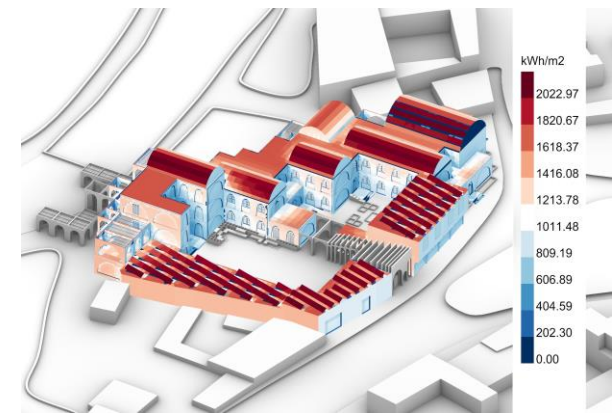
How to integrate active renewable systems with HVAC systems?



Dynamic simulation flow chart



The TRNSYS model of the proposed trigeneration system

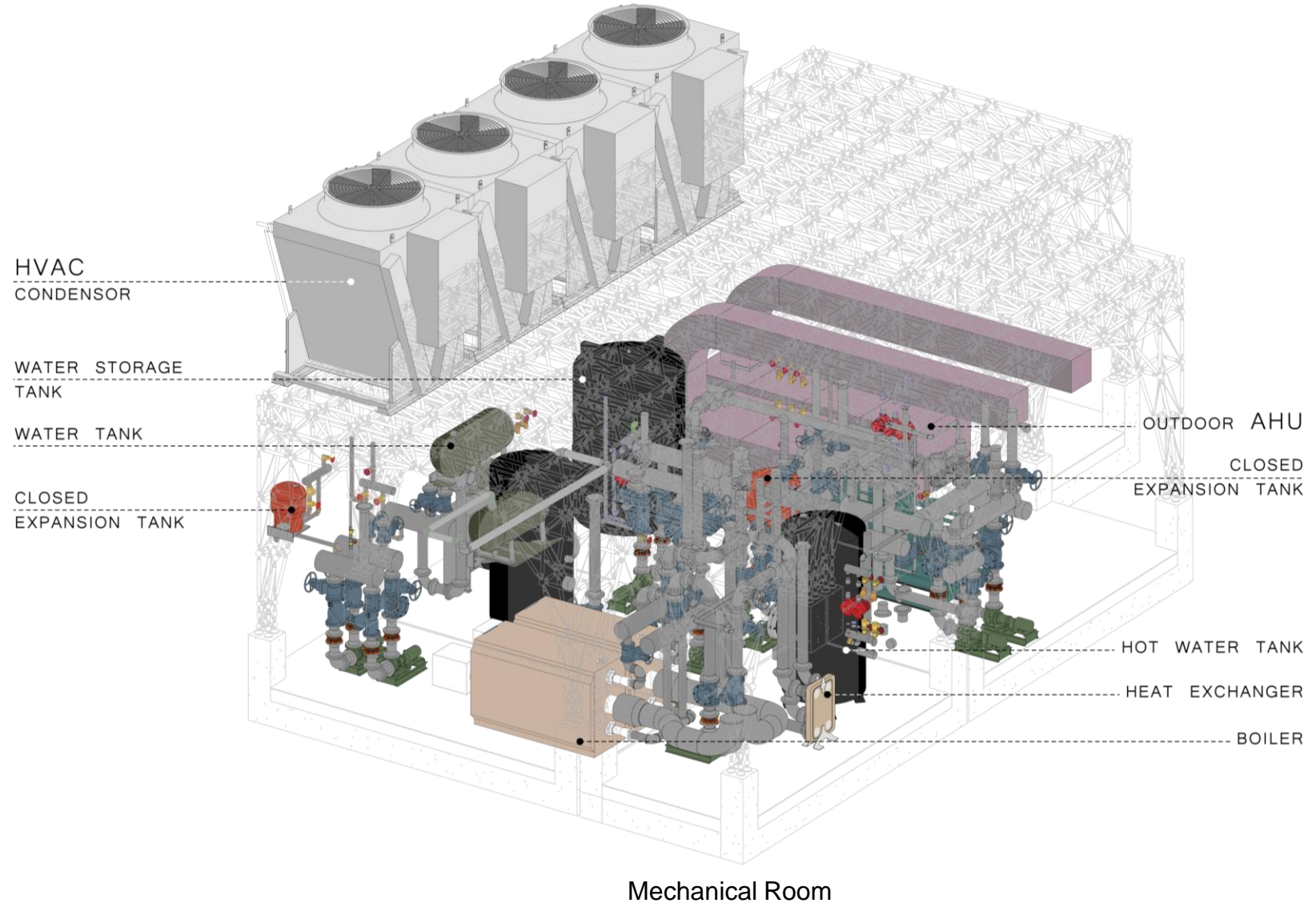


Total Solar Radiation on the Building



How did we supply heating, cooling, and DHW loads?

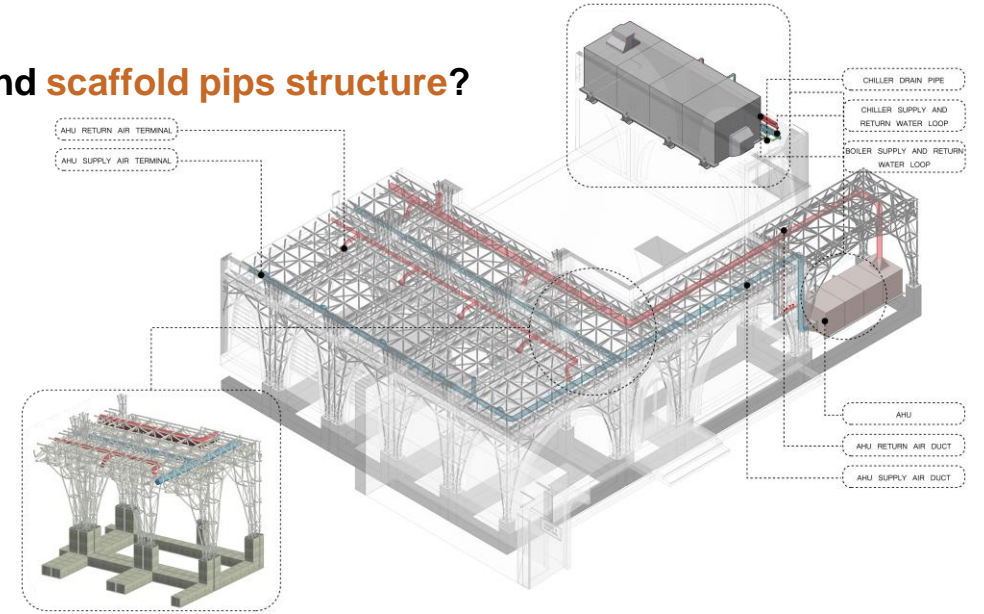
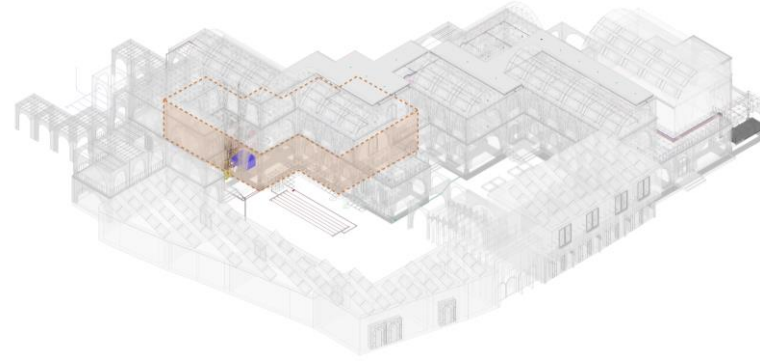
- 1 --- Introducing the team
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- 3 --- Software
- 4 --- Site context
- 5 --- Project Highlights:
 - 5.1 --- Architecture
 - 5.2 --- **Engineering**
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 - 5.4 --- Efficiency
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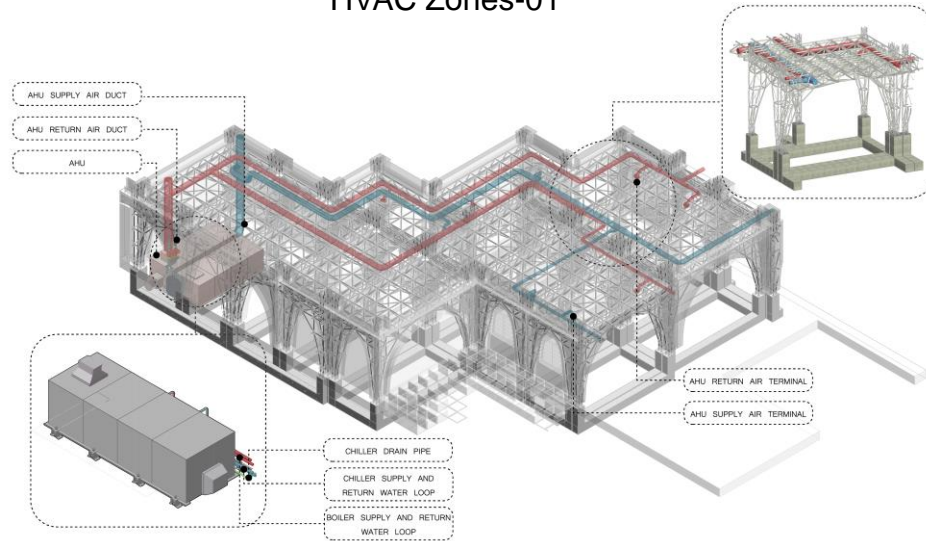


- 1 --- Introducing the team
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- 3 --- Software
- 4 --- Site context
- 5 --- Project Highlights:
 - 5.1 --- Architecture
 - 5.2 --- **Engineering**
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How do air ducts pass through the second-hand scaffold pips structure?



HVAC Zones-01



Zone-01 AHU Supply and Return Ducts

Zone-02 AHU Supply and Return Ducts

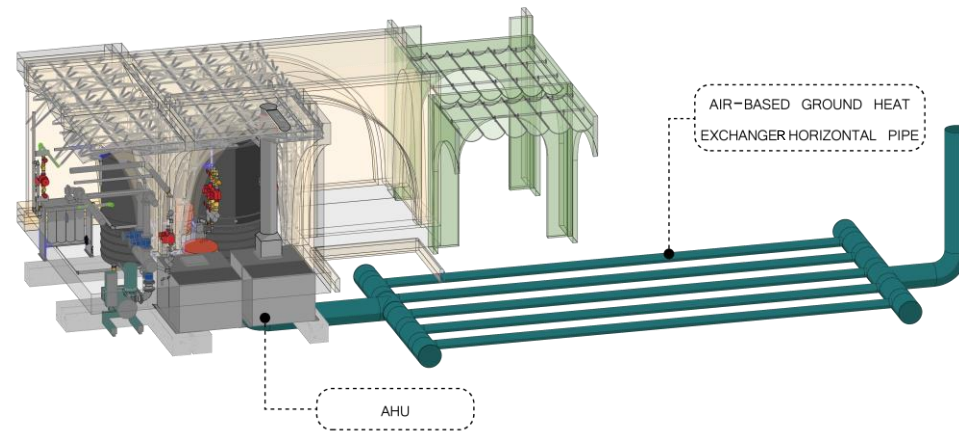


HVAC Zones-02

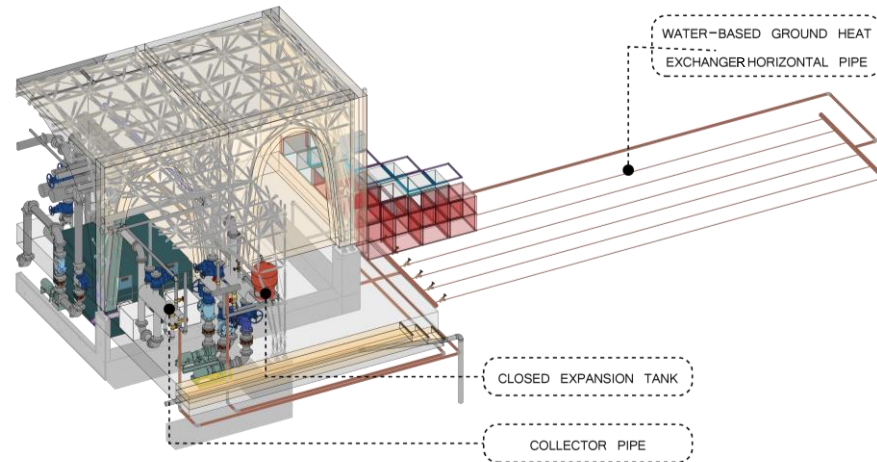


- 1 --- Introducing the team
- 2 --- Design goals
- 3 --- Software
- 4 --- Site context
- 5 --- Project Highlights:
 - 5.1 --- Architecture
 - 5.2 --- **Engineering**
 - 5.3 --- Envelope
 - 5.4 --- Efficiency
 - 5.5 --- Grid-Interactivity
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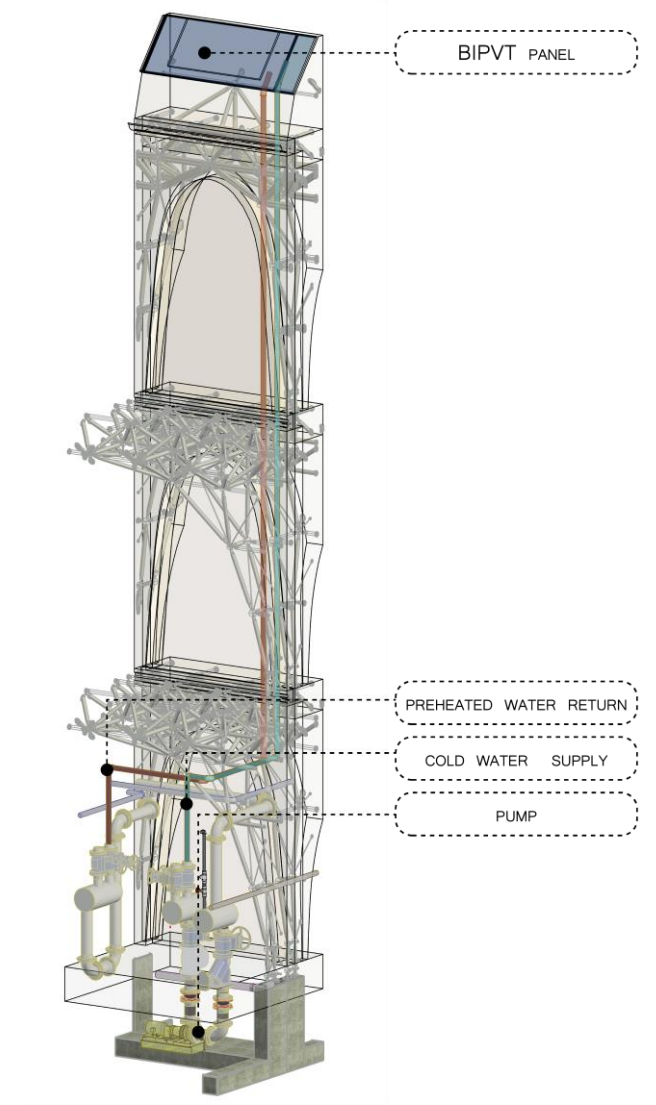
How to generate on-site renewable energy?



Air-Based Ground Heat Exchanger:



Water-Based Ground Heat Exchanger:

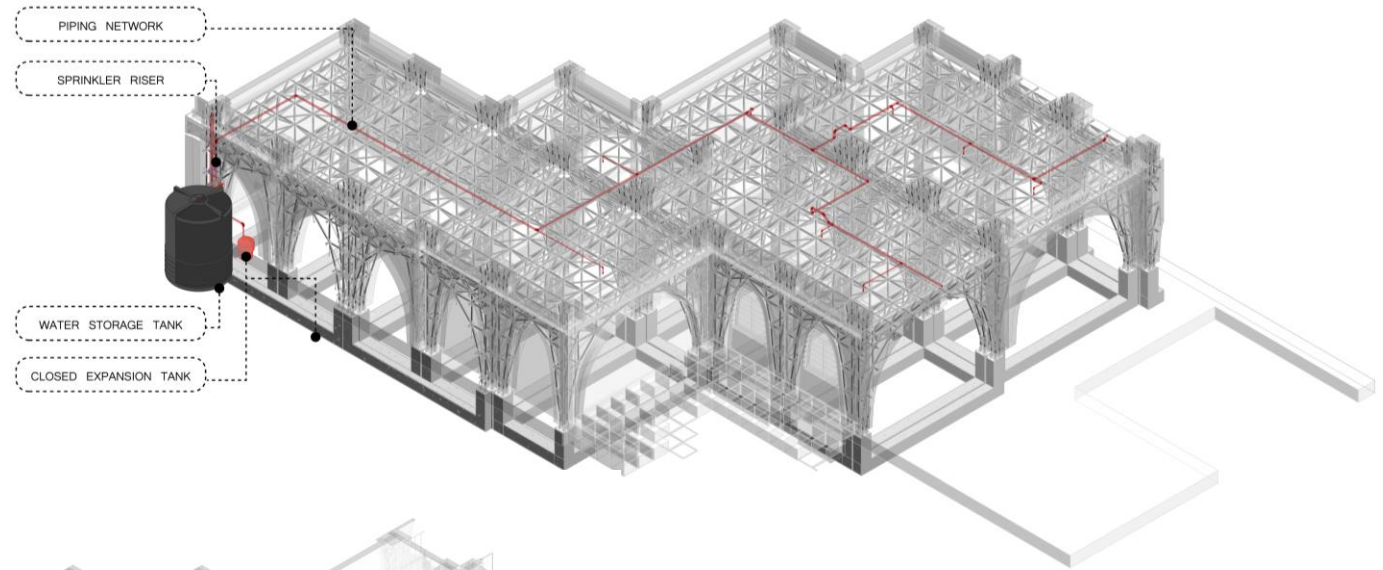


BIPVT hot water system:

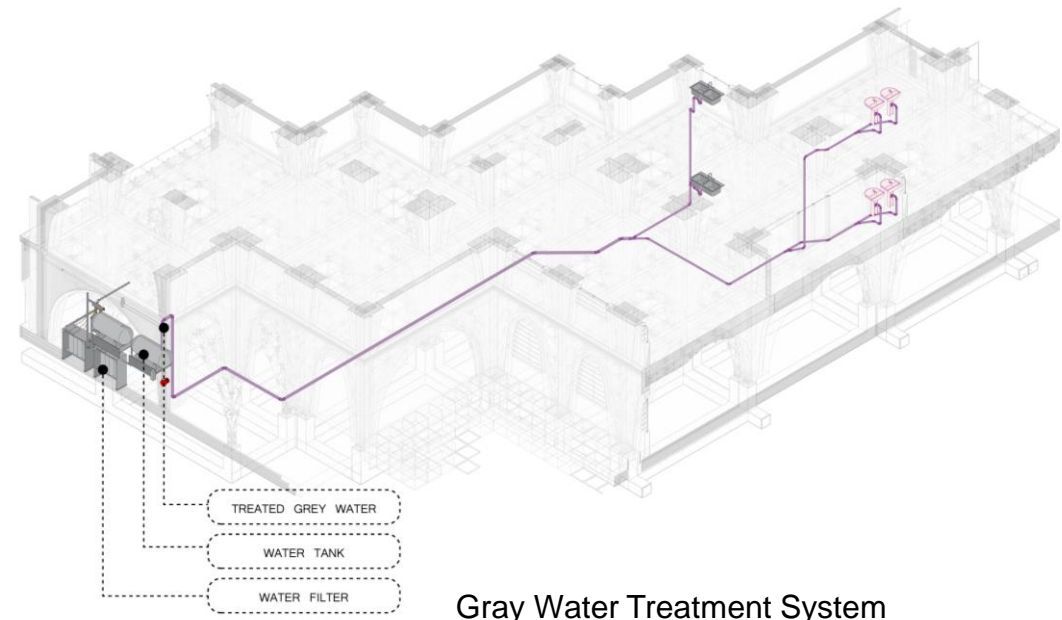


- 1 - - - - - Introducing the team
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What did we do about **fire protection** and **water recovery** systems?



Fire Protection System

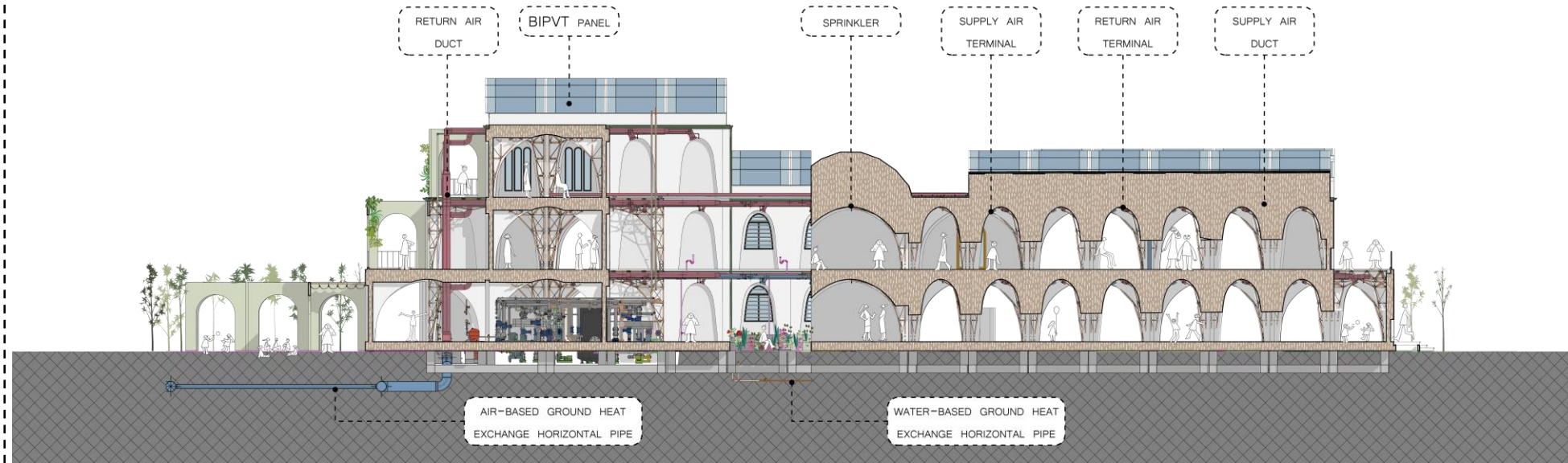


Gray Water Treatment System

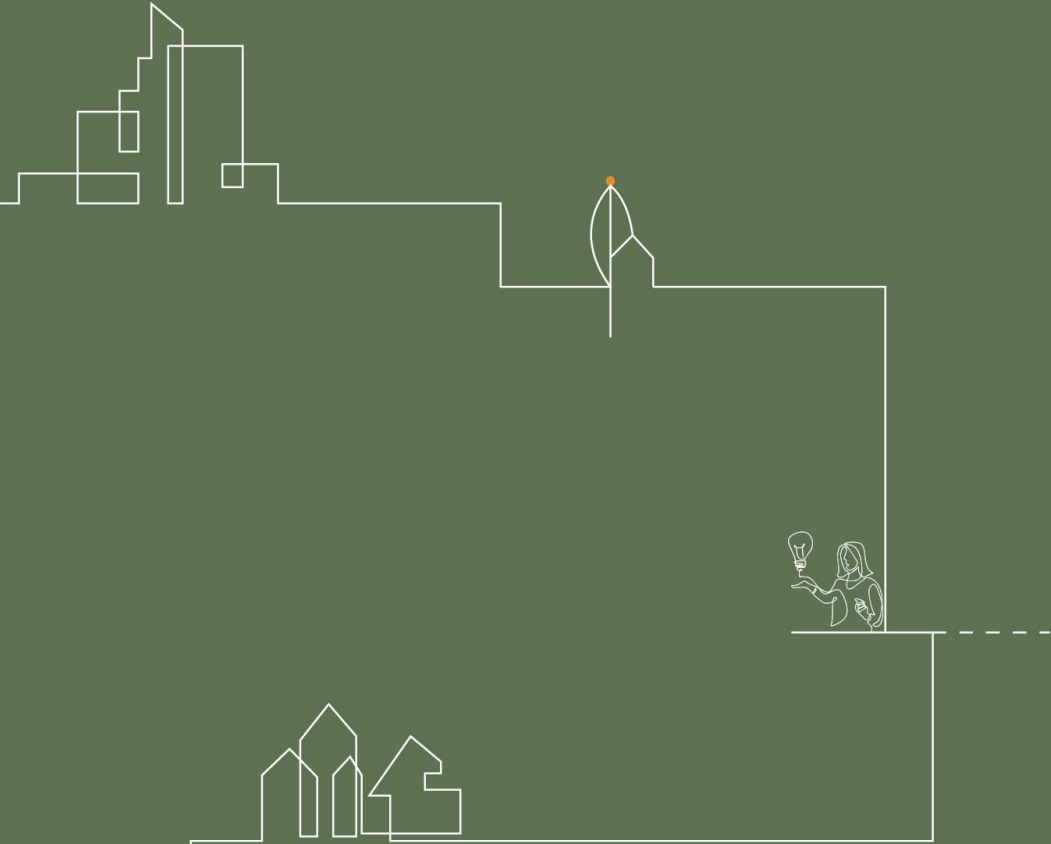


Technical section:

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5.3

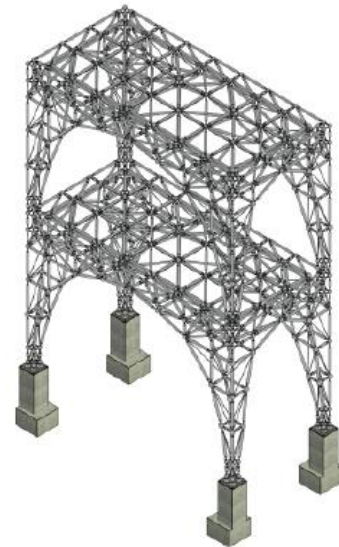
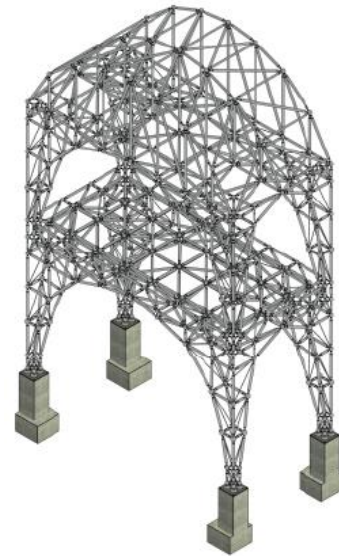


Envelope

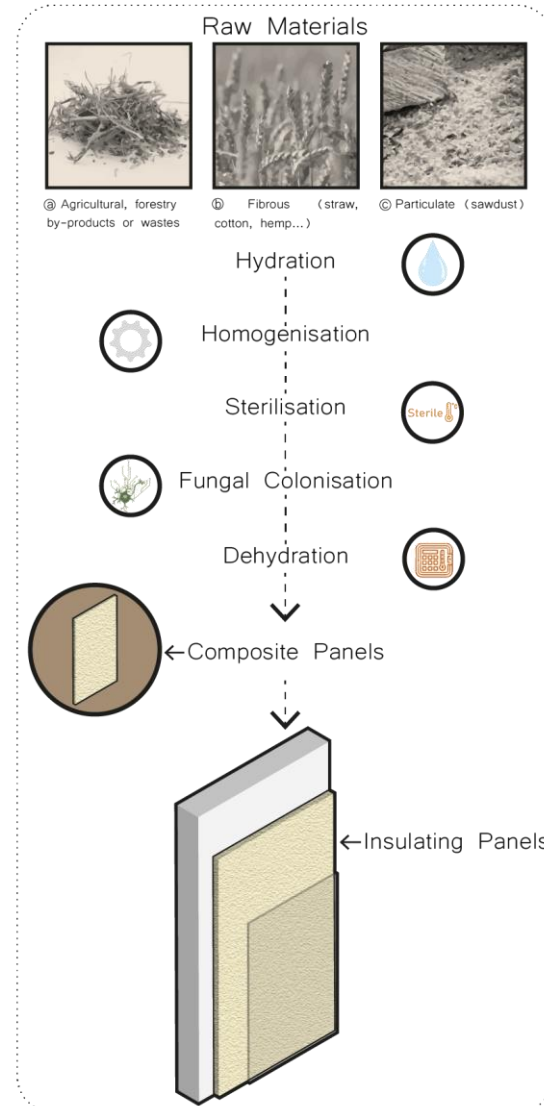


- 1 - Introducing the team
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 - 5.2 - Engineering
 - 5.3 - Envelope
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 - 5.5 - Grid-Interactivity
 - 5.6 - Life-Cycle
 - 5.7 - Health
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 - 5.9 - Community

What Innovative Materials did we use?

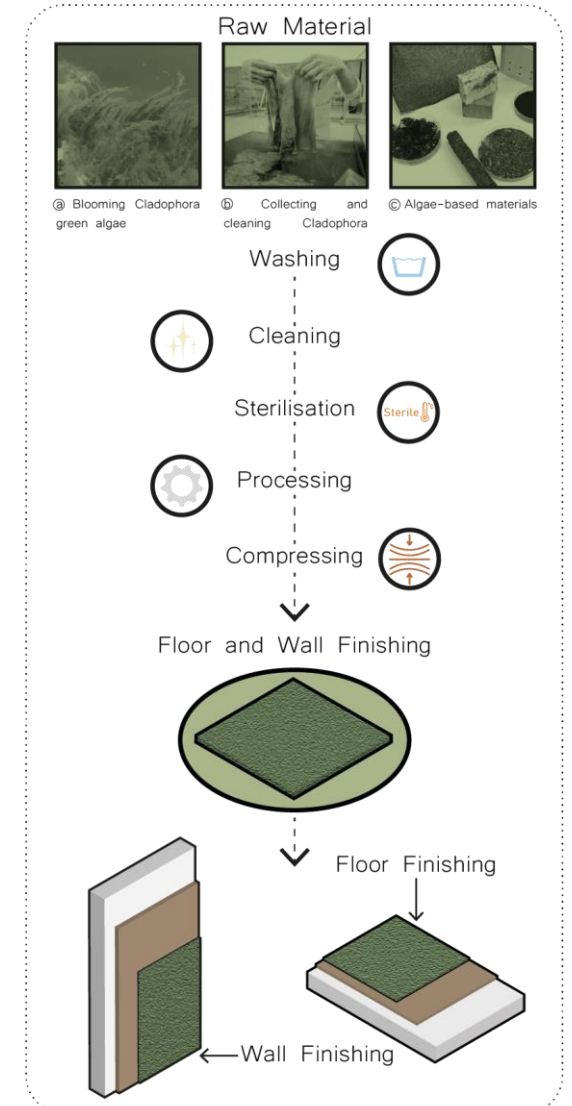


Second-Hand Scaffold Pipes



Manufacturing process of mycelium composites.

Mycelium Wheat Thermal Insulation



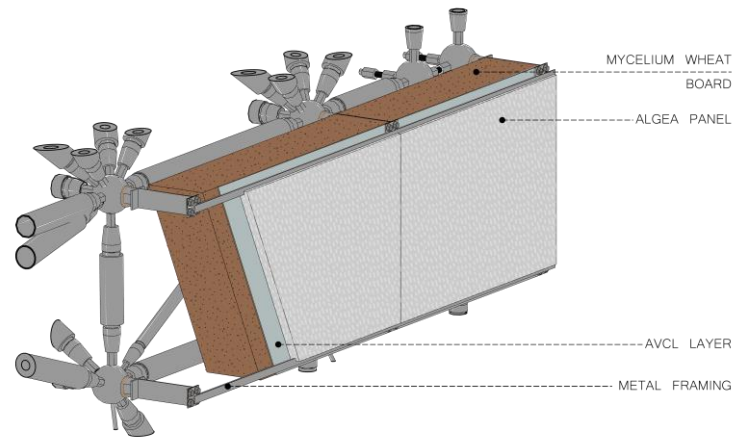
Manufacturing process of algae tiles.

Algae Tile

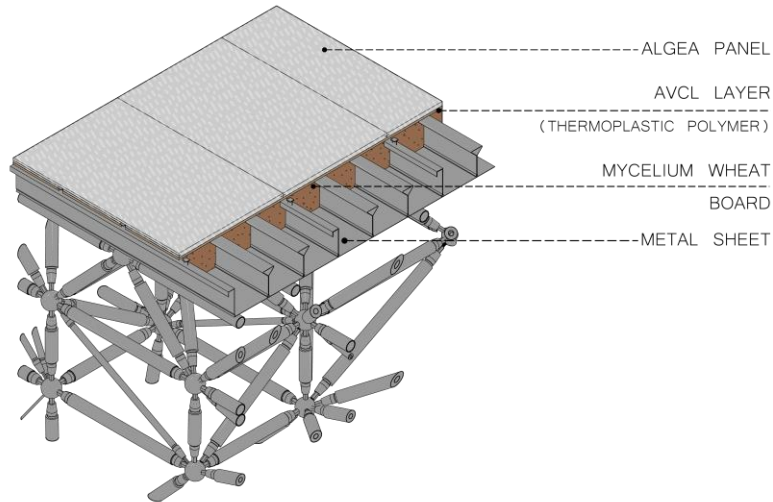


- 1 - - - - - Introducing the team
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- 3 - - - - - Software
- 4 - - - - - Site context
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- 5.3 - - - - - **Envelope**
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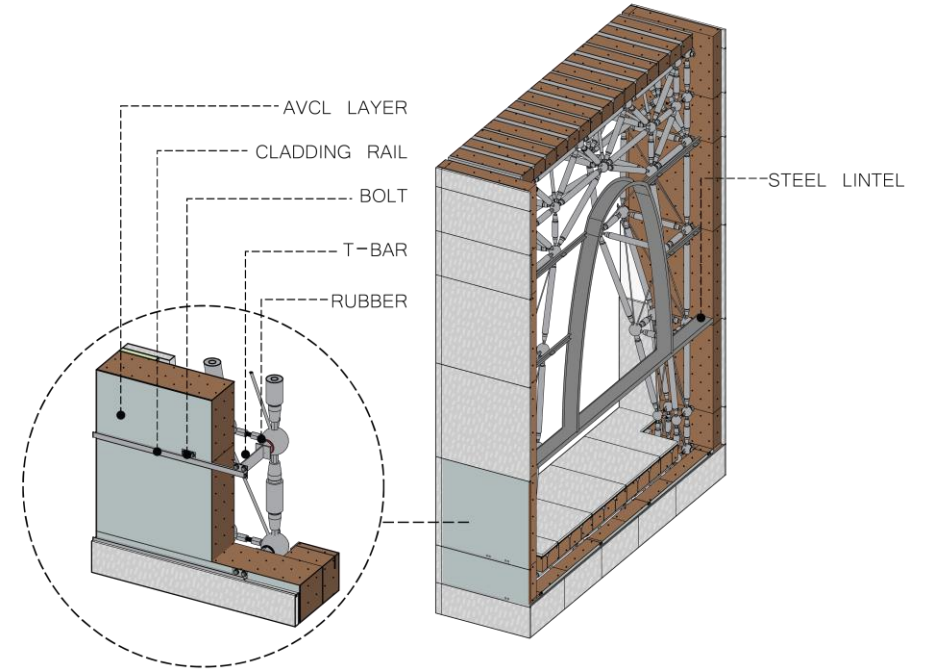
How did we design the **new building envelope**?



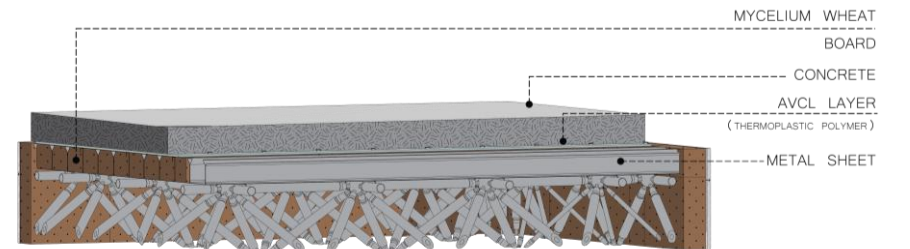
External Wall Layers



Internal Floor Layers



Windows Structure

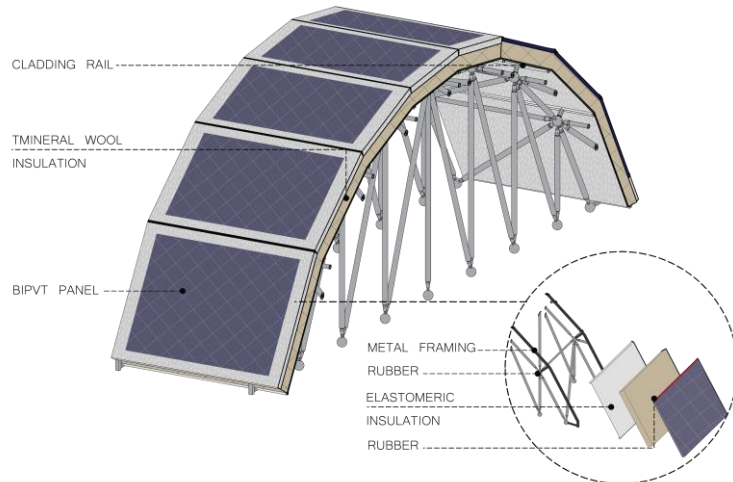


Flat Roof Layers

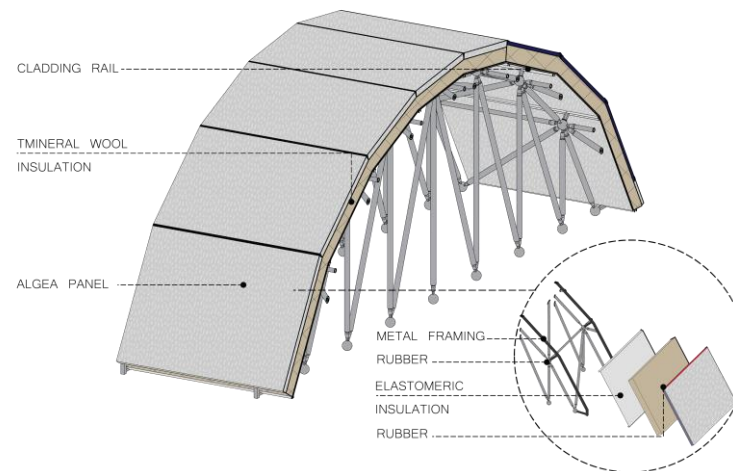


- 1 - - - - - Introducing the team
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- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
- 5.1 - - - - - Architecture
- 5.2 - - - - - Engineering
- 5.3 - - - - - Envelope
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- 5.5 - - - - - Grid-Interactivity
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- 5.7 - - - - - Health
- 5.8 - - - - - Market
- 5.9 - - - - - Community

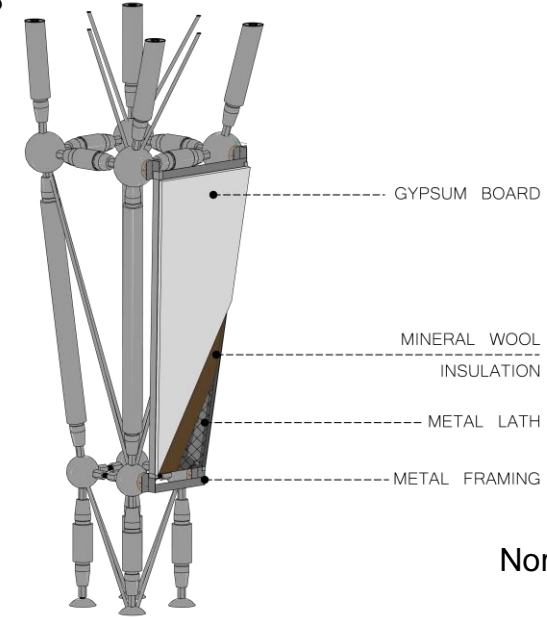
How did we design the **new building envelope**?



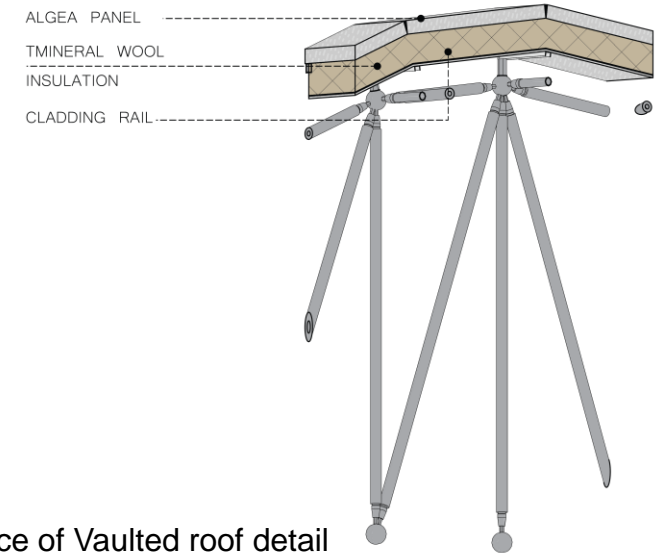
South Face of Vaulted roof detail



North Face of Vaulted roof detail



North Face of Vaulted roof detail



North Face of Vaulted roof detail



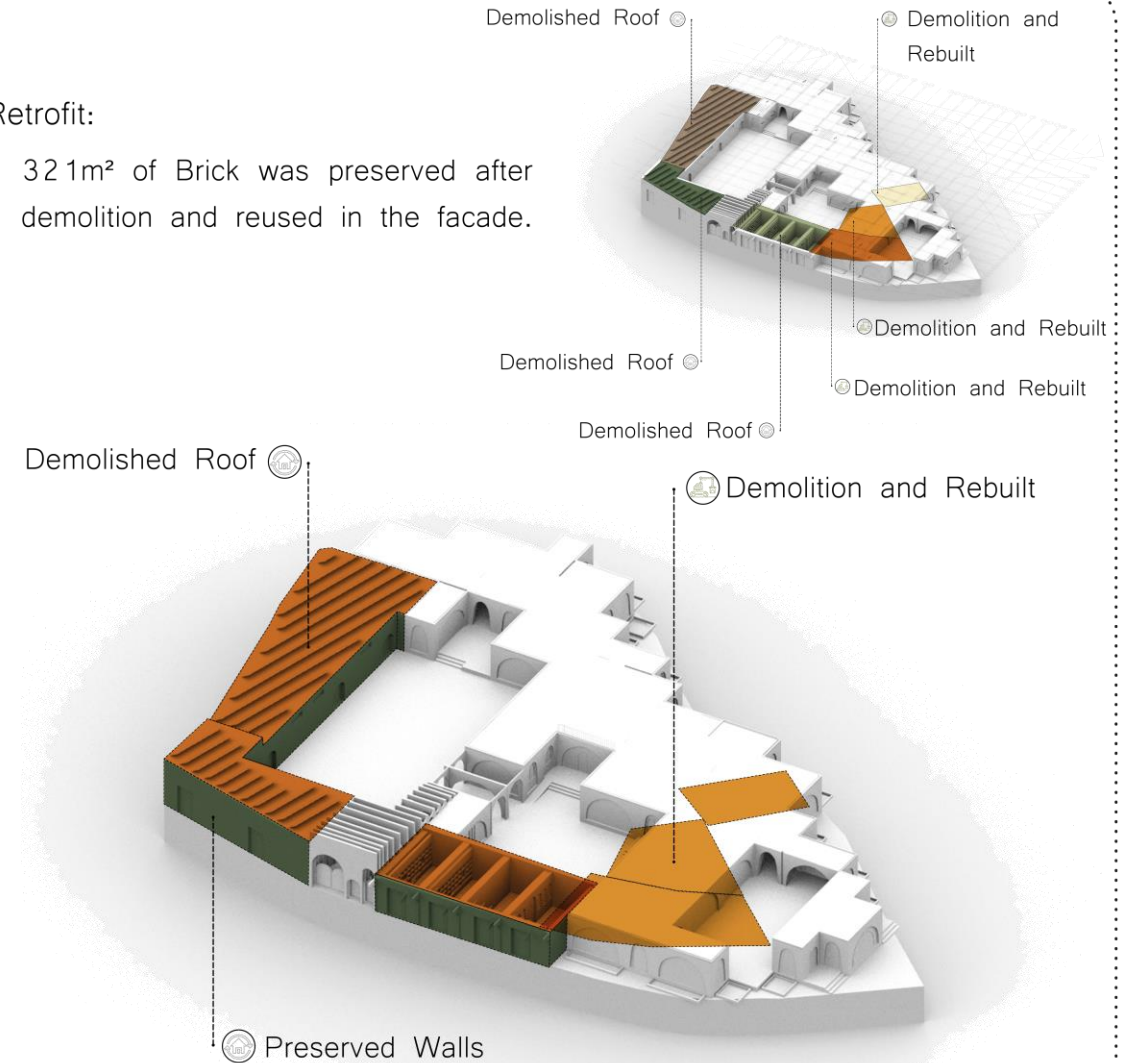
- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
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How did we retrofit the existing building envelope?


Retrofit Envelope	
Total Envelope (m ³)	1178.30
Total Demolition (m ³)	371.75
Total Preserved (m ³)	806.55
Total Demolition (%)	32%
Total Preserved (%)	68%

Retrofit:

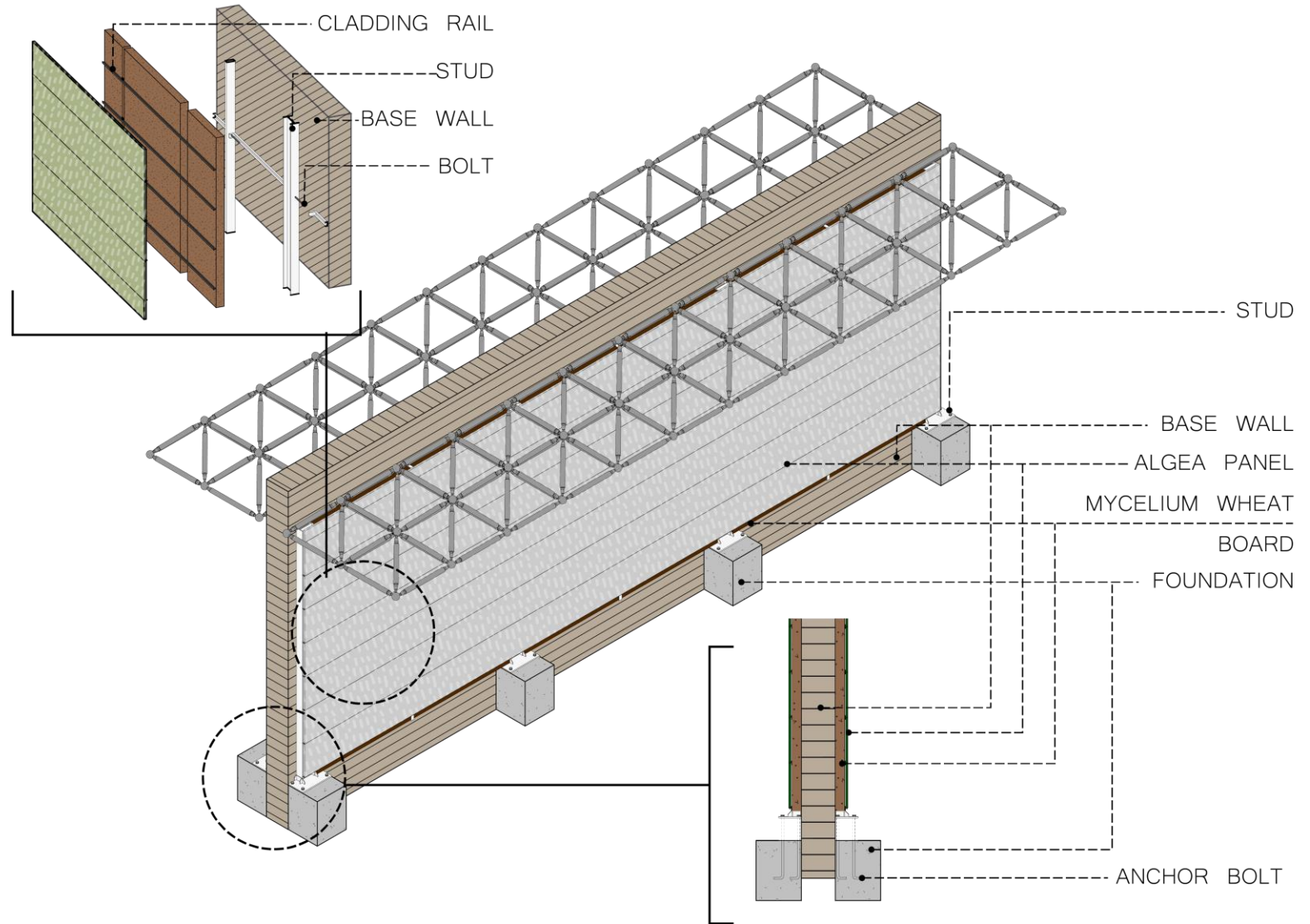
321m² of Brick was preserved after demolition and reused in the facade.





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 - 5.3  --- Envelope
 - 5.4 --- Efficiency
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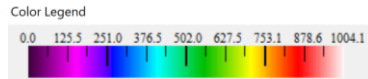
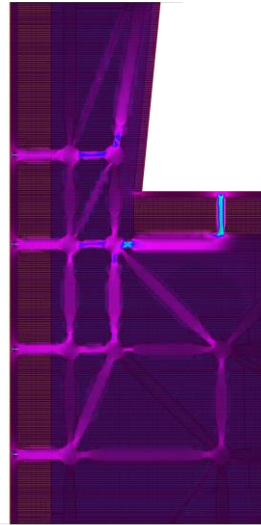
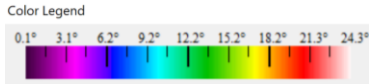
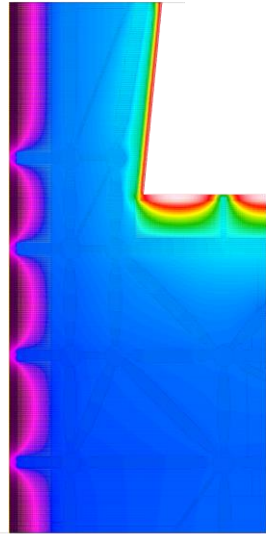
How did we **reinforce** the retrofitted building's **structure**?



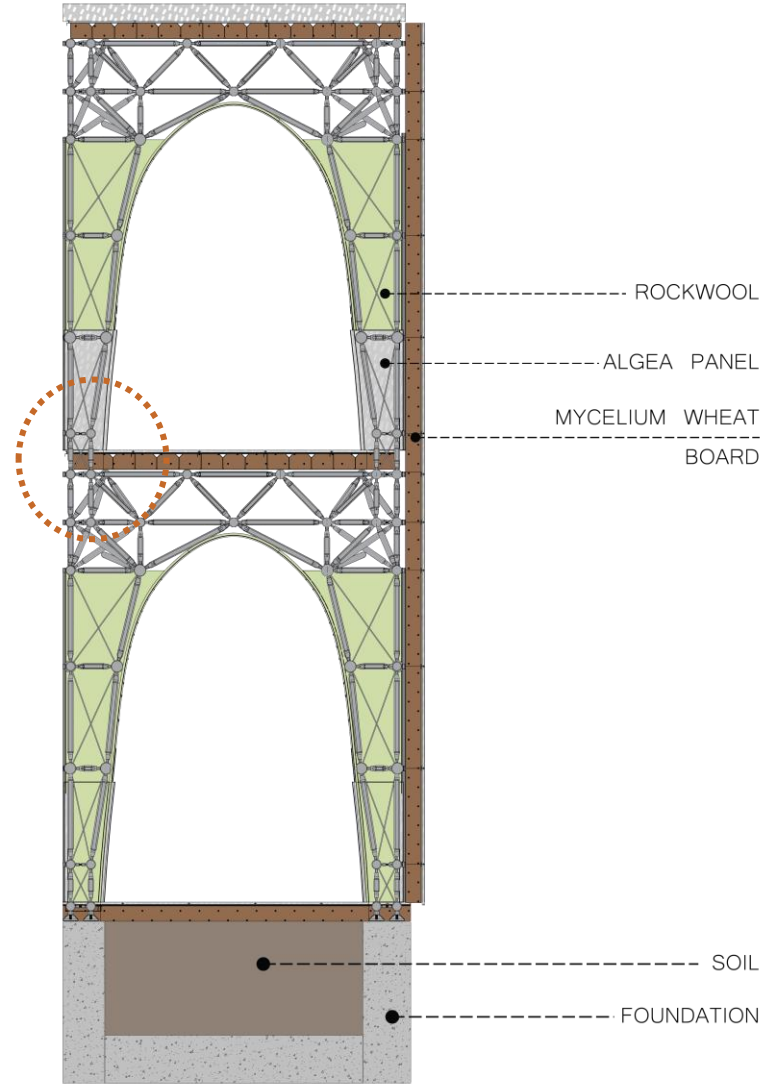
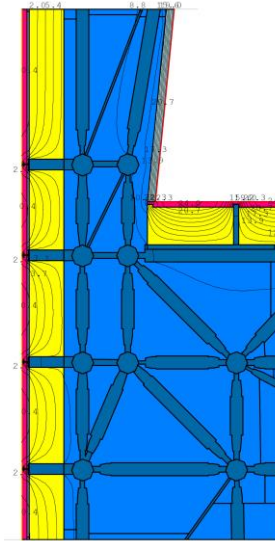


How did we solve the thermal bridges?

- 1 --- Introducing the team
- 2 --- Design goals
- 3 --- Software
- 4 --- Site context
- 5 --- Project Highlights:
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 - 5.2 --- Engineering
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Thermal Bridge Analysis



Wall Section



- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
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- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
- 5.1 - - - - - Architecture
- 5.2 - - - - - Engineering
- 5.3 - - - - - Envelope
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New building envelope thermal characteristics:

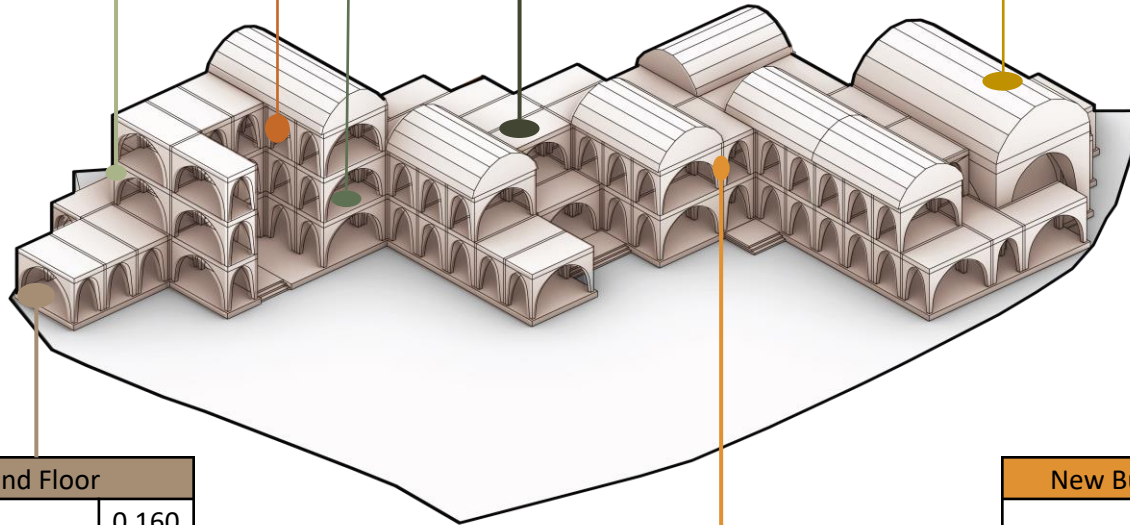
New Building External Wall	
Thickness (m)	0.485
U-Value (W/m ² .K)	0.209
R-Value (m ² .K/W)	4.790
Required R-Value* (m ² .K/W)	1.800

New Building Internal Floor	
Thickness (m)	0.692
U-Value (W/m ² .K)	0.355
R-Value (m ² .K/W)	2.817
Required R-Value* (m ² .K/W)	-

New Building Semi-Exposed Floor	
Thickness (m)	0.592
U-Value (W/m ² .K)	0.237
R-Value (m ² .K/W)	4.210
Required R-Value* (m ² .K/W)	1.400

New Building External Flat Roof	
Thickness (m)	0.753
U-Value (W/m ² .K)	0.219
R-Value (m ² .K/W)	4.550
Required R-Value* (m ² .K/W)	3.600

New Building External Vault Roof	
Thickness (m)	0.285
U-Value (W/m ² .K)	2.150
R-Value (m ² .K/W)	4.650
Required R-Value* (m ² .K/W)	3.600



New Building Ground Floor	
Thickness (m)	0.160
U-Value (W/m ² .K)	0.269
R-Value (m ² .K/W)	3.710
Referenced R-Value* (m ² .K/W)	1.400

New Building Semi-Exposed Internal wall	
Thickness (m)	0.654
U-Value (W/m ² .K)	0.355
R-Value (m ² .K/W)	2.850
Required R-Value* (m ² .K/W)	1.600

* According to Iranian Building Code No. 19



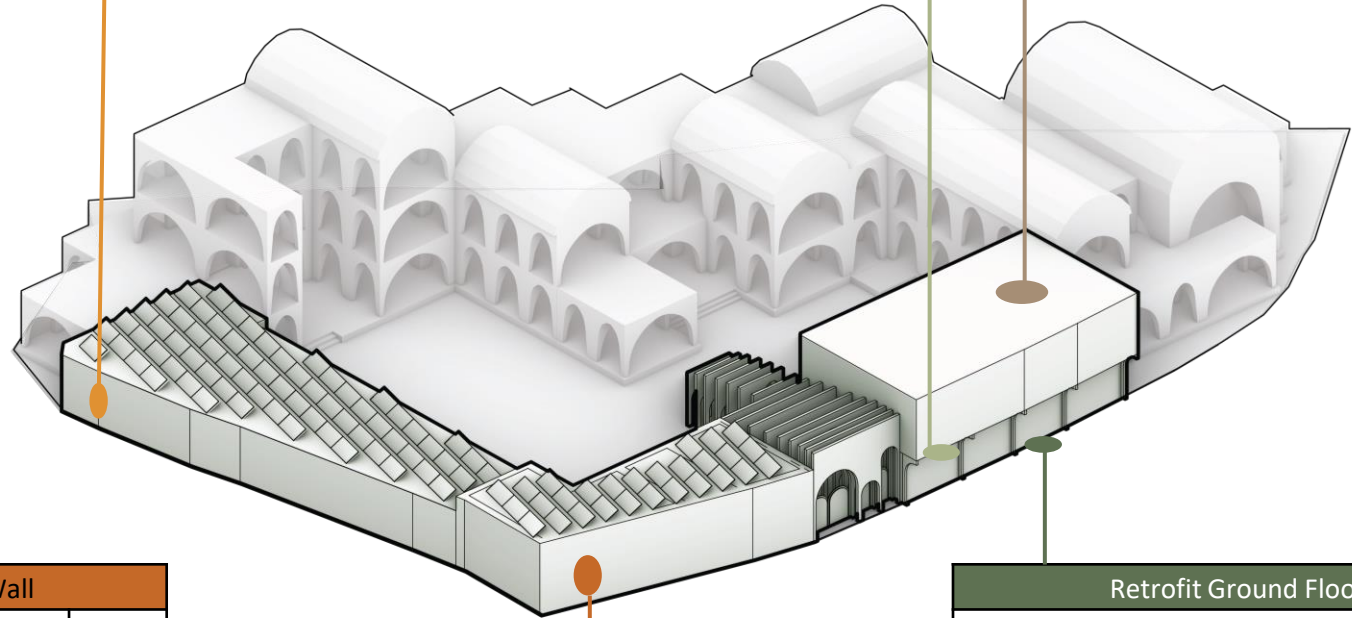
- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
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Retrofit building envelope thermal characteristics:

Retrofit Semi-Exposed Wall	
Thickness (m)	0.680
U-Value (W/m ² .K)	0.240
R-Value (m ² .K/W)	4.150
Required R-Value* (m ² .K/W)	1.600

Retrofit Semi-Exposed Floor	
Thickness (m)	0.690
U-Value (W/m ² .K)	0.308
R-Value (m ² .K/W)	4.46
Required R-Value* (m ² .K/W)	1.400

Retrofit External Roof	
Thickness (m)	0.743
U-Value (W/m ² .K)	0.222
R-Value (m ² .K/W)	4.500
Required R-Value* (m ² .K/W)	3.600

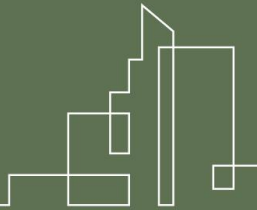


Retrofit External Wall	
Thickness (m)	0.680
U-Value (W/m ² .K)	0.240
R-Value (m ² .K/W)	4.150
Required R-Value* (m ² .K/W)	1.800

Retrofit Ground Floor	
Thickness (m)	0.190
U-Value (W/m ² .K)	0.334
R-Value (m ² .K/W)	3.000
Required R-Value* (m ² .K/W)	1.400

* According to Iranian Building Code No. 19

5.4



Efficiency

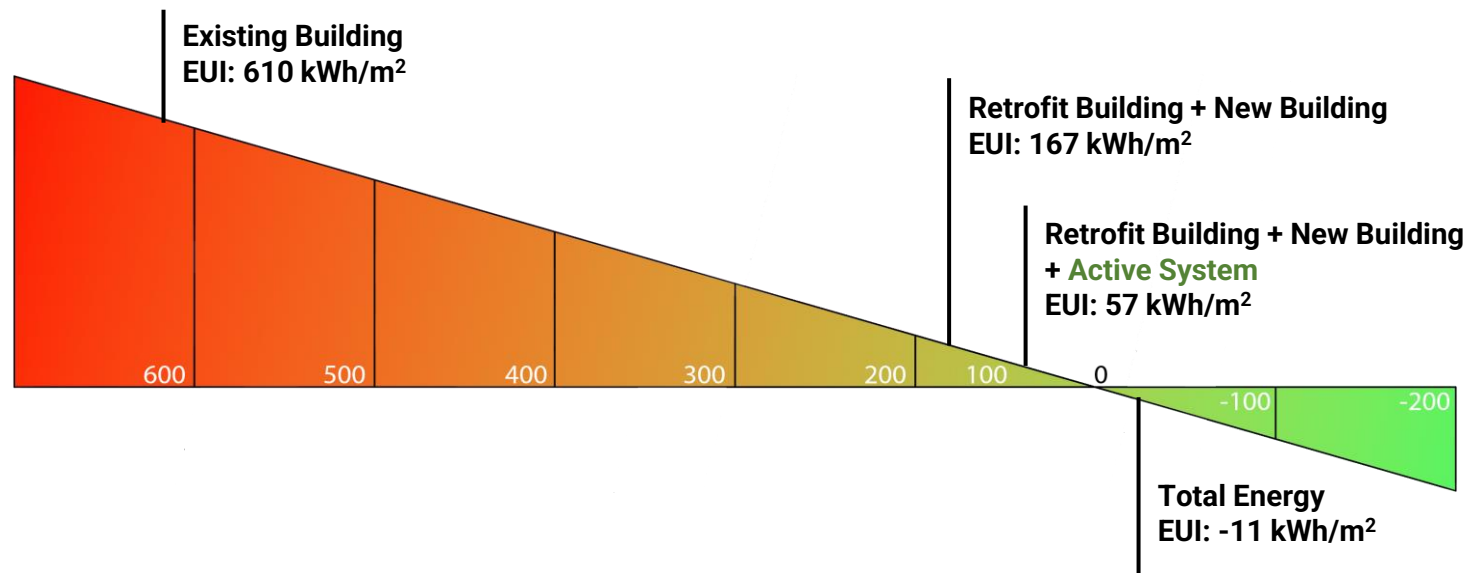


- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
- 5.1 - - - - - Architecture
- 5.2 - - - - - Engineering
- 5.3 - - - - - Envelope
- 5.4 - - - - - **Efficiency**
- 5.5 - - - - - Grid-Interactivity
- 5.6 - - - - - Life-Cycle
- 5.7 - - - - - Health
- 5.8 - - - - - Market
- 5.9 - - - - - Community

45

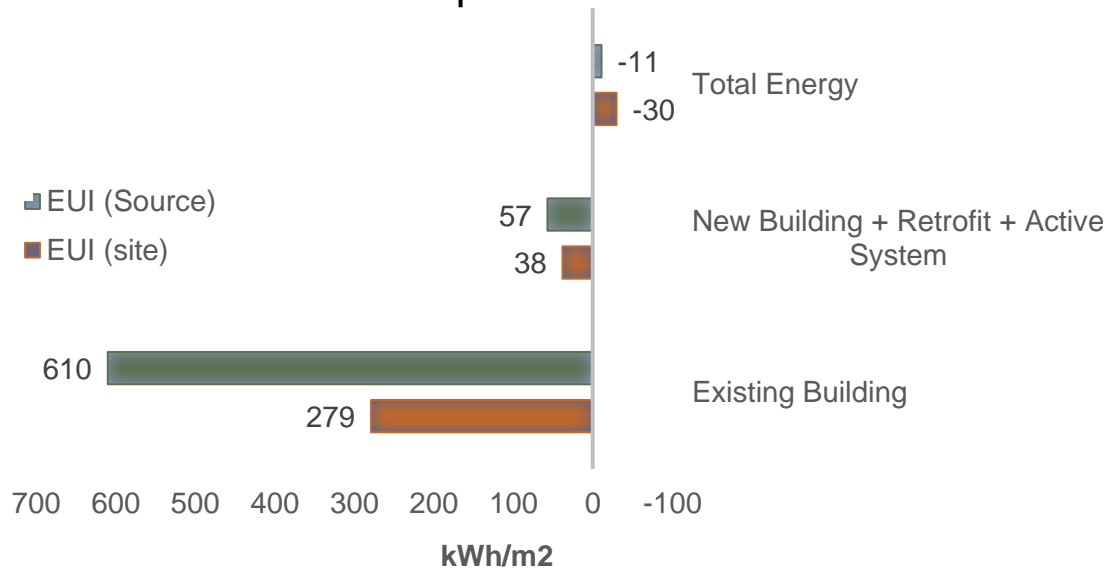
81

How did we reach the zero energy target?



Energy Target

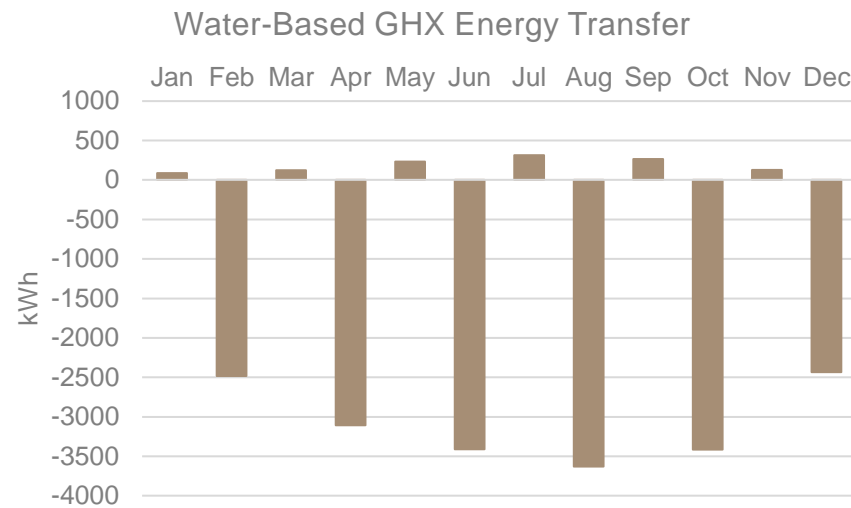
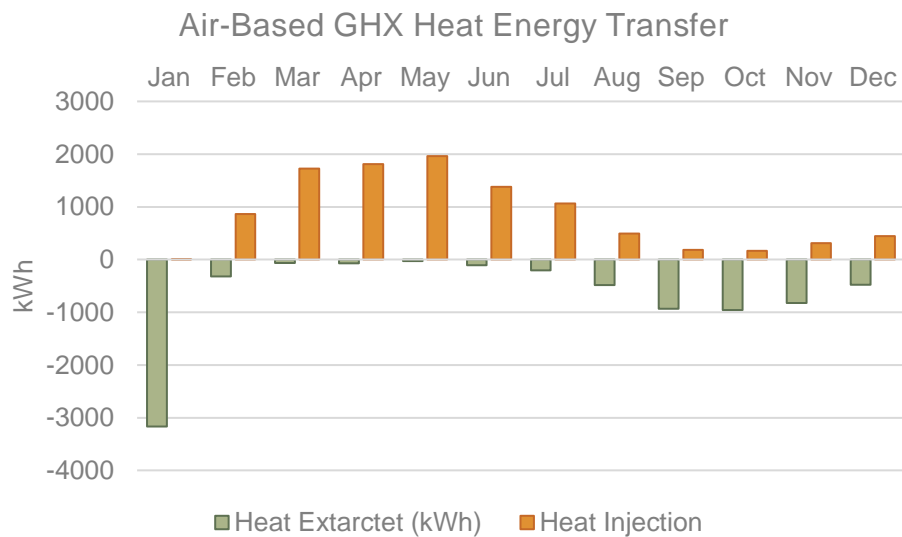
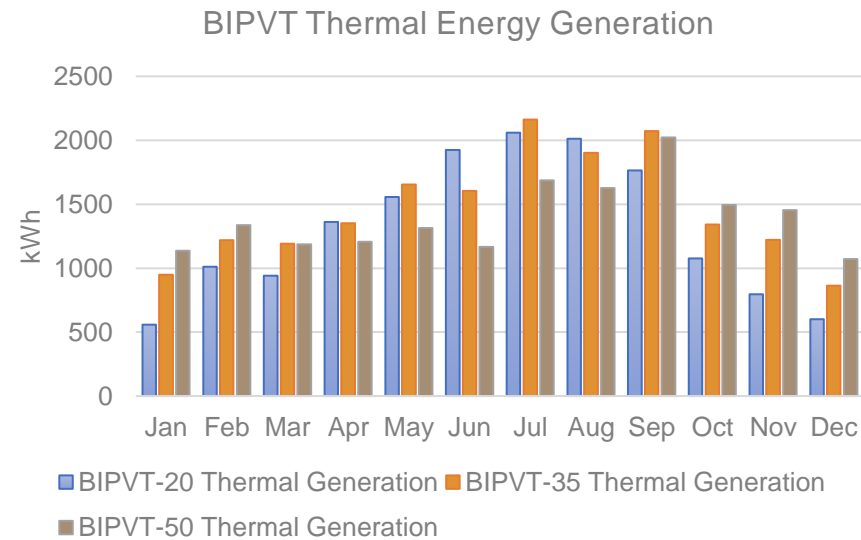
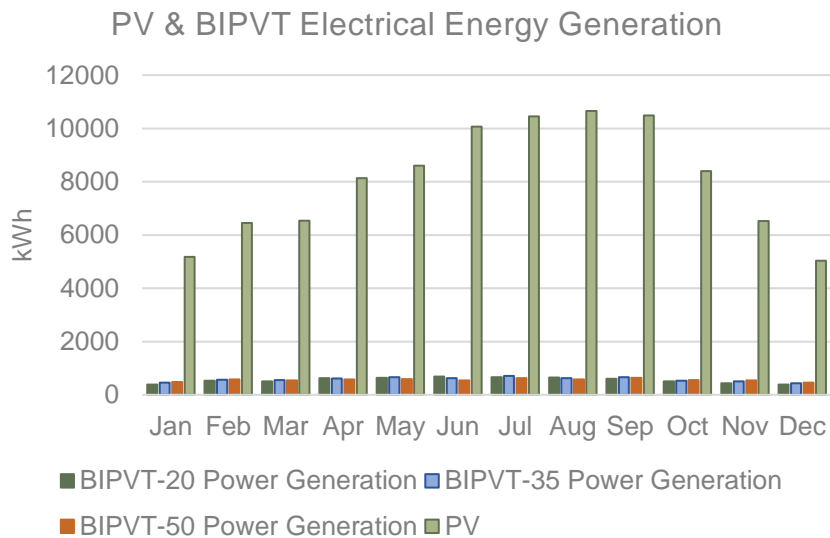
IRAN Zero Energy EUI Target	25 kWh/m²/yr
Existing Building Site EUI	279 EUI
Existing Building Source EUI	610 EUI
Site Energy	81.85 EUI
Source Energy	167.23 EUI
Site Active Energy	80.77 EUI
Site EUI + Active System	38.43 EUI
Source EUI+ Active System	56.90 EUI
Total Site EUI	-29.77 EUI
Total Source EUI	-11.30 EUI





- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
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- 5.2 - - - - - Engineering
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- 5.5 - - - - - Grid-Interactivity
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- 5.7 - - - - - Health
- 5.8 - - - - - Market
- 5.9 - - - - - Community

How much energy did the active systems generate?





- 1 --- Introducing the team
- 2 --- Design goals
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 - 5.3 --- Envelope
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47

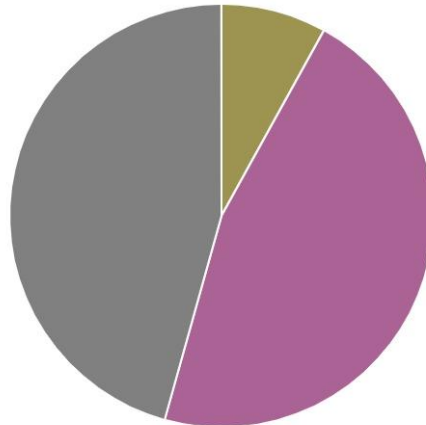
81

How much carbon did the energy systems emit?

New building

Global warming kg CO2e - Classifications

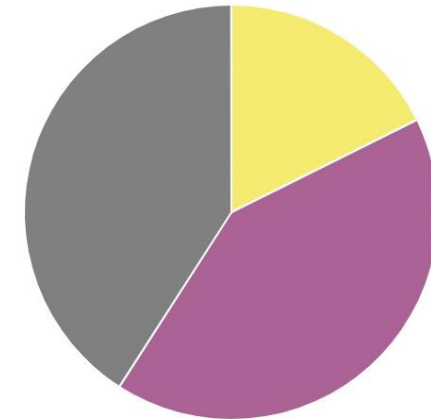
- 1.1 Foundations (substructure)
- 1.2 In-built lighting system
- 1.3.1 Ground floor slab
- 1.3.3 Stairs and ramps
- 1.4 Facades
- 1.4.2 Façade openings
- 2.2 In-built lighting system
- 2.3 Energy system - 8.0%
- 2.4.1 Air handling units
- Fuel use - 46.3%
- Electricity use - 45.7%
- Other classifications



Existing building

Global warming kg CO2e - Classifications

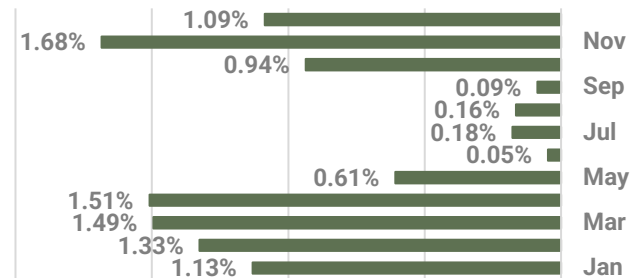
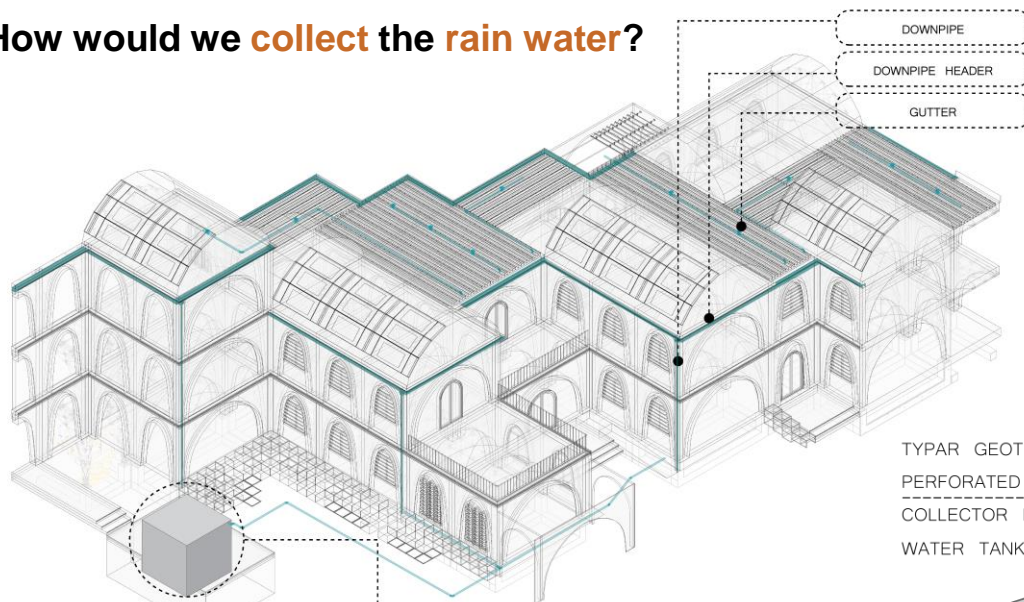
- 1.2.1 Frame (beams, columns and slabs)
- 1.2.3 External walls
- 1.3.1 Ground floor slab
- 2.2 In-built lighting system
- 2.3 Energy system - 17.7%
- 2.4.1 Air handling units
- 3. External works
- Fuel use - 41.4%
- Electricity use - 40.9%
- Other classifications



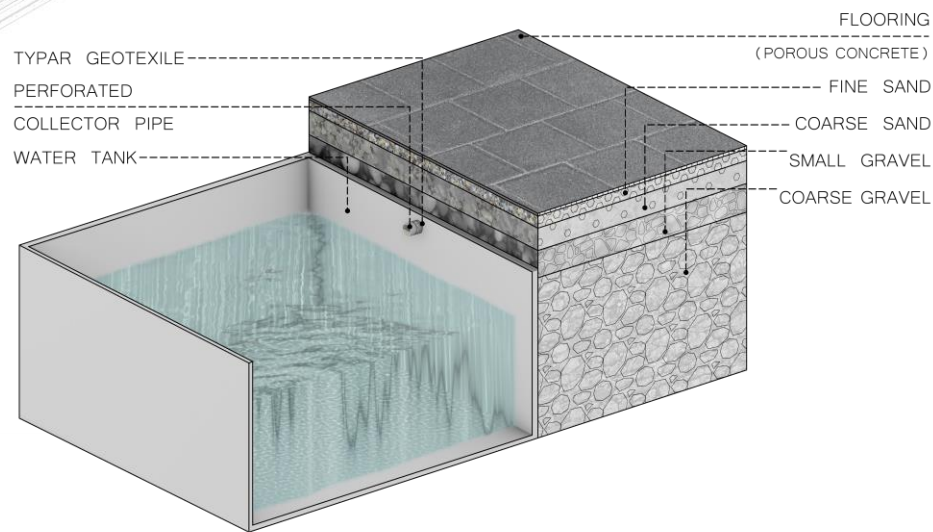
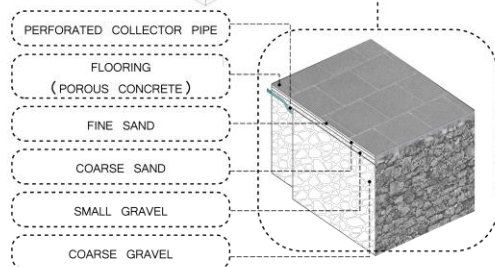


- 1 --- Introducing the team
- 2 --- Design goals
- 3 --- Software
- 4 --- Site context
- 5 --- Project Highlights:
 - 5.1 --- Architecture
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 - 5.3 --- Envelope
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 - 5.5 --- Grid-Interactivity
 - 5.6 --- Life-Cycle
 - 5.7 --- Health
 - 5.8 --- Market
 - 5.9 --- Community

How would we collect the rain water?



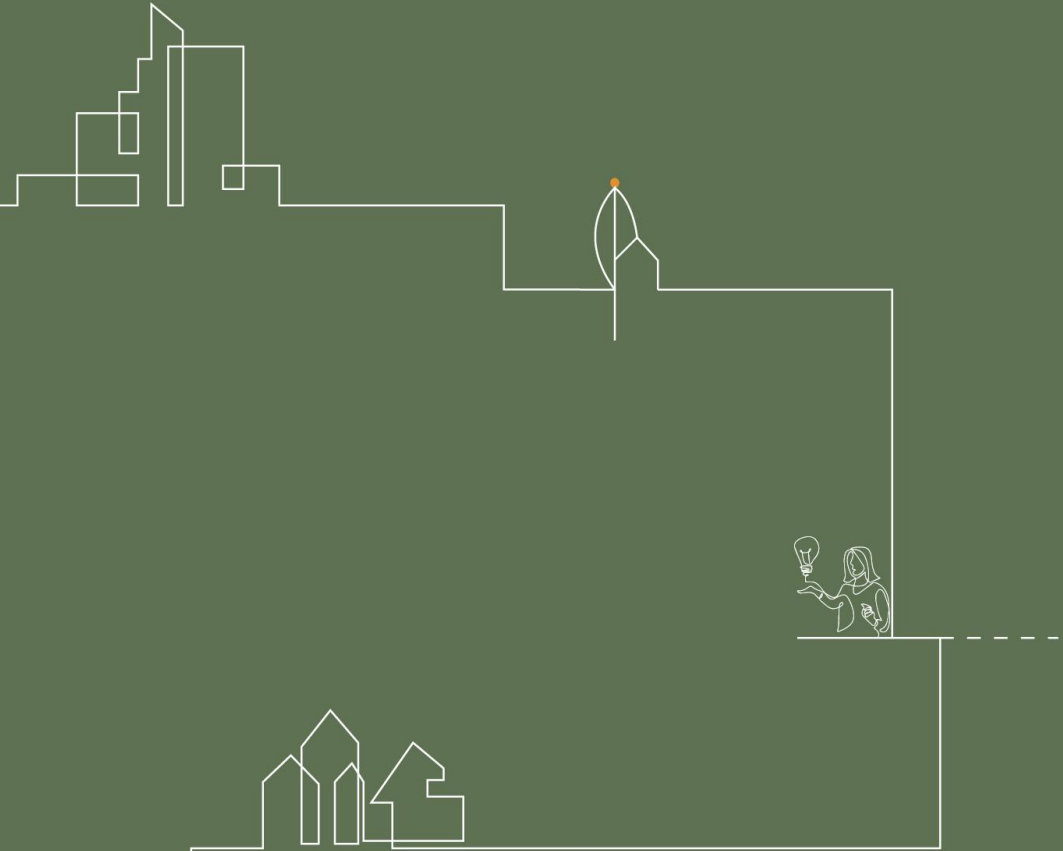
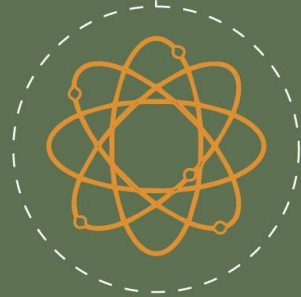
Average annual rainfall in Tehran



Annual water consumption

Building Type	Number of Occupants	Occupant Water Usage (liter/person.day)	Daily Water Usage (m ³ /day)	Active Days Per Year	Annual Water Usage (m ³ /year)	Daily Recovered Water (liter/day)	Annual Water Saving (%)
Retrofit (Restaurant)	15	90	1.35	365	492.7	90	7
New Building	150	13	1.95	300	585.0	900	46

5.5



Grid-Interactivity



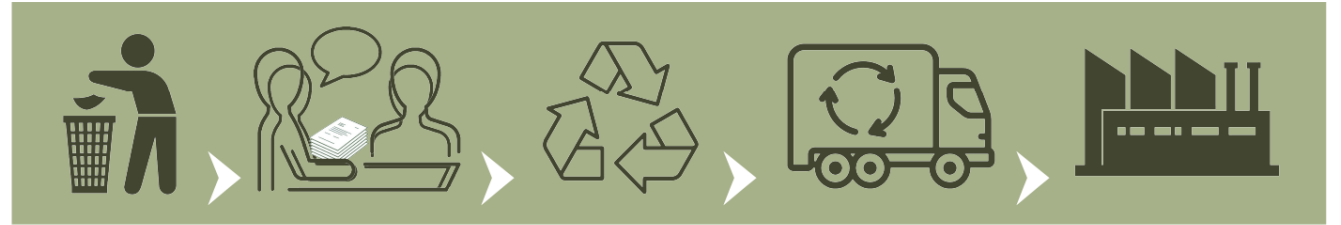
- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
 - 5.1 - - - - - Architecture
 - 5.2 - - - - - Engineering
 - 5.3 - - - - - Envelope
 - 5.4 - - - - - Efficiency
 - 5.5 - - - - - **Grid-Interactivity**
 - 5.6 - - - - - Life-Cycle
 - 5.7 - - - - - Health
 - 5.8 - - - - - Market
 - 5.9 - - - - - Community

How would we **interact** to the **grid**?

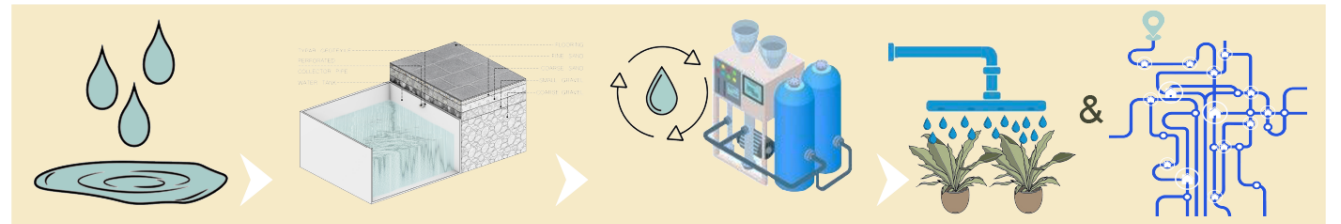
Generating extra electricity and selling it to grid.



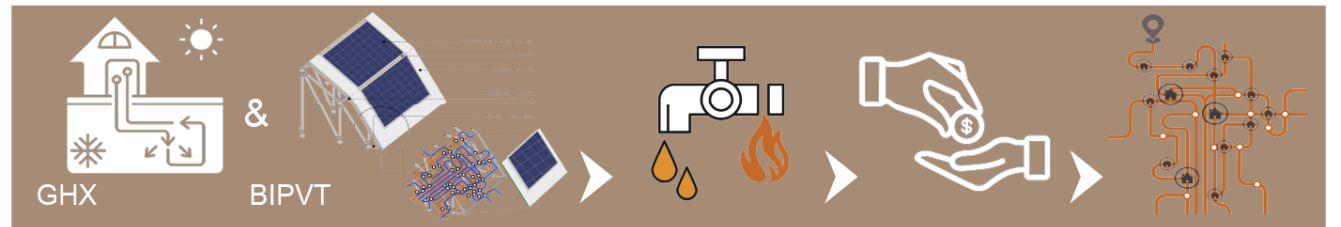
Collecting waste and sending it for recycling.



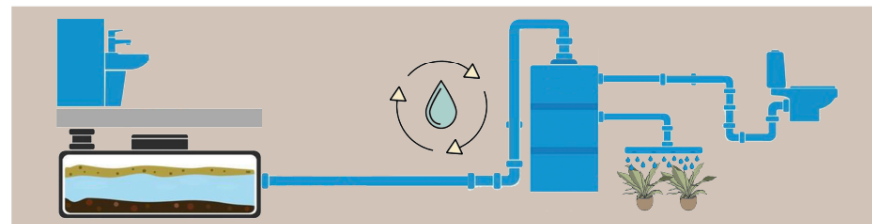
Collecting rainwater and refining, using it for irrigating plants and supplying to the grid.



Generating hot water from geothermal energy and solar panel's excess heat emission.



Collecting and refining graywater for reuse in services and plant irrigation.



Save the future

5.6



Life-Cycle



How would students learn about carbon emissions?

- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
 - 5.1 - - - - - Architecture
 - 5.2 - - - - - Engineering
 - 5.3 - - - - - Envelope
 - 5.4 - - - - - Efficiency
 - 5.5 - - - - - Grid-Interactivity
 - 5.6 - - - - - **Life-Cycle**
 - 5.7 - - - - - Health
 - 5.8 - - - - - Market
 - 5.9 - - - - - Community

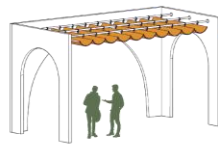


Mycelium Wheat Garden

What do you think we can do with the remaining fabrics?

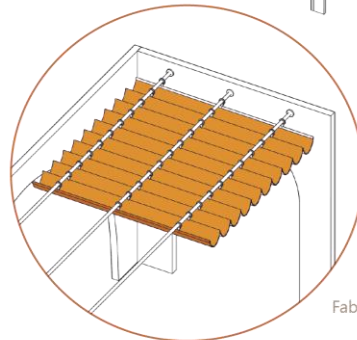
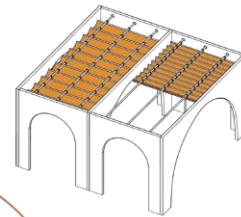


We can use them to make the movable shading for Eyvan and exhibition stands both



Architecture Module of Eyvan

Movable Fabric Shading



Tension Cable



Fabrics Roll

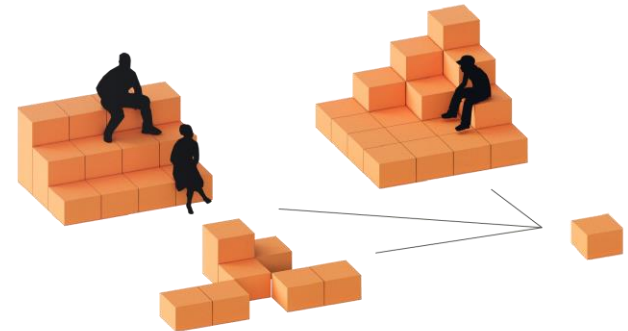
Don't do this. We can reuse them by combining textile waste and ecological glue, and produce a kind of brick to make flexible outdoor furniture



Textile Waste : 80%
Ecological glue : 20%



We have a lot of pieces of cloth that we throw away every day.



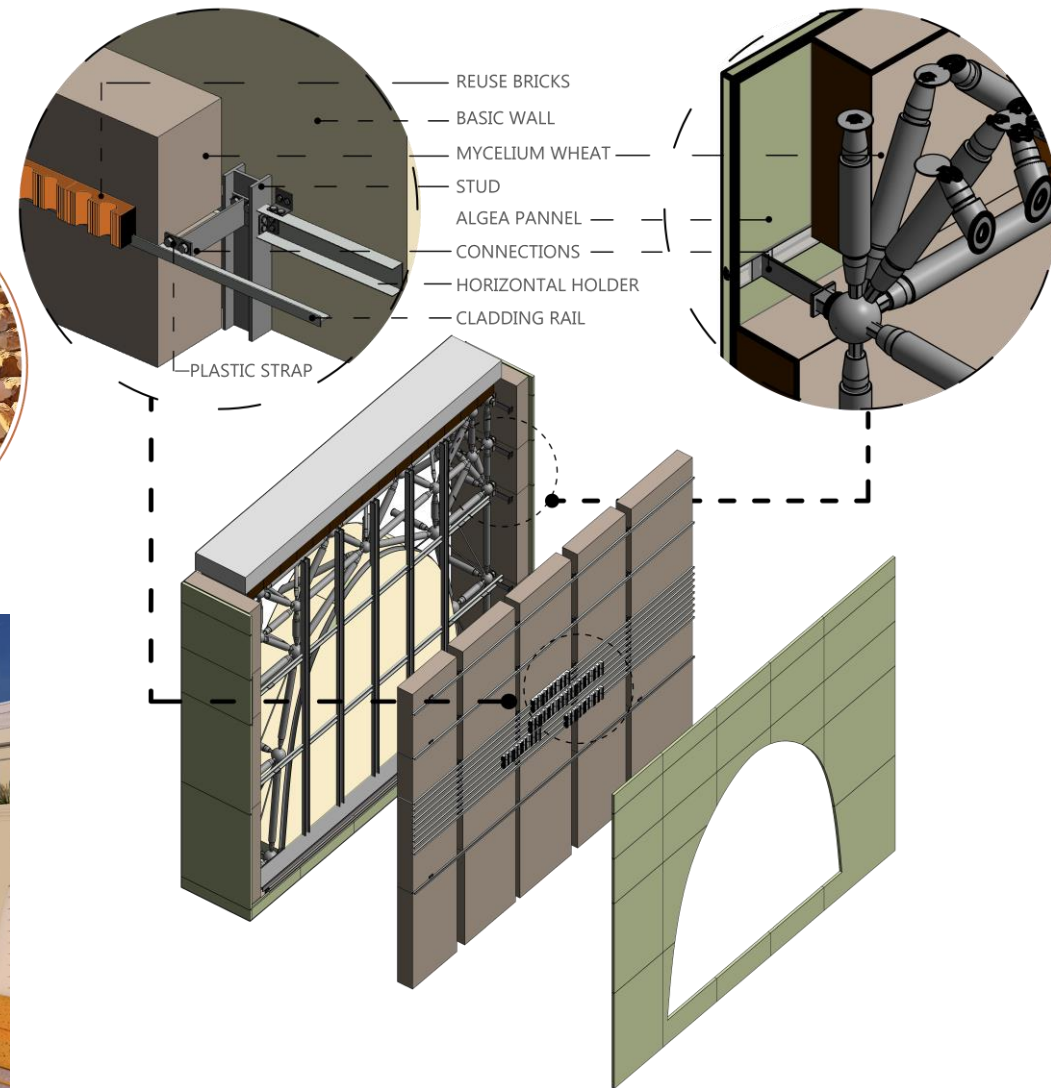
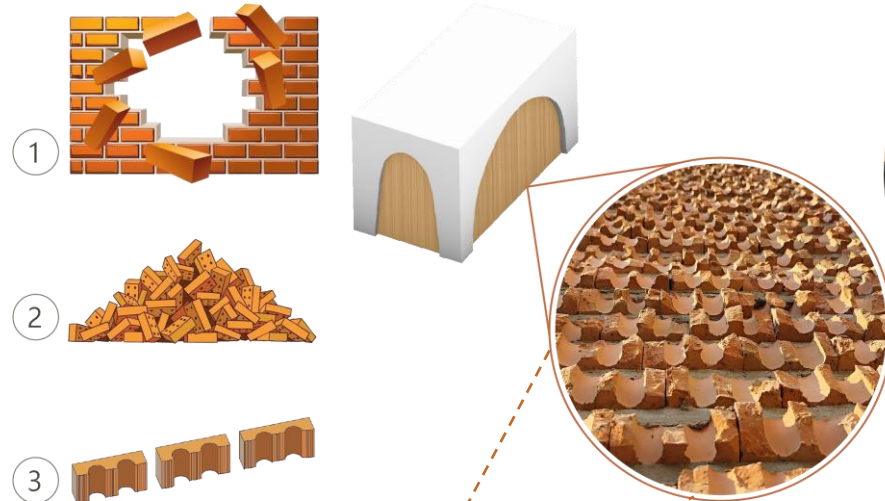
Outdoor Cubic Furniture



- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
 - 5.1 - - - - - Architecture
 - 5.2 - - - - - Engineering
 - 5.3 - - - - - Envelope
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 - 5.5 - - - - - Grid-Interactivity
 - 5.6 Life-Cycle
 - 5.7 - - - - - Health
 - 5.8 - - - - - Market
 - 5.9 - - - - - Community

How would we reuse the bricks from Demolition?

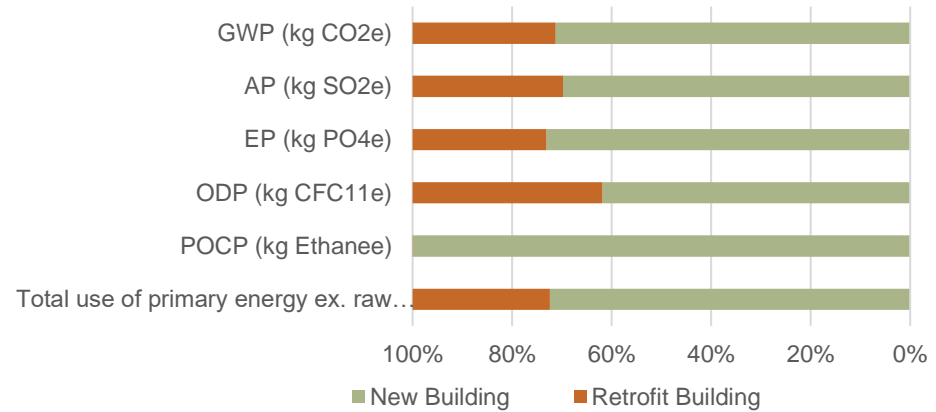
Bricks from Demolition were preserved and reused





- 1 --- Introducing the team
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- 5.4 --- Efficiency
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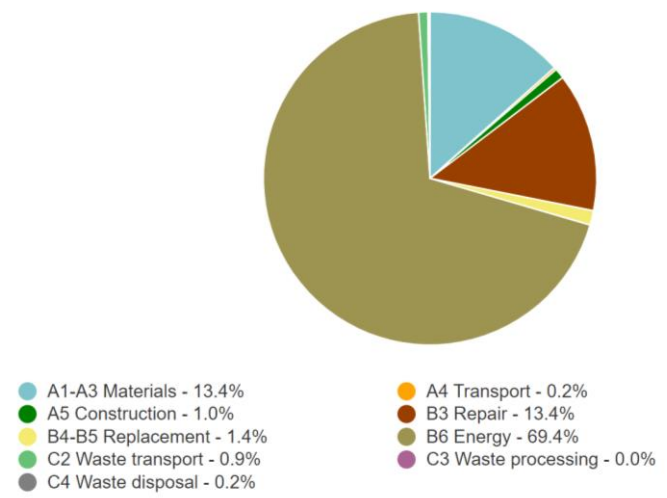
How did we calculate the life-cycle emission?



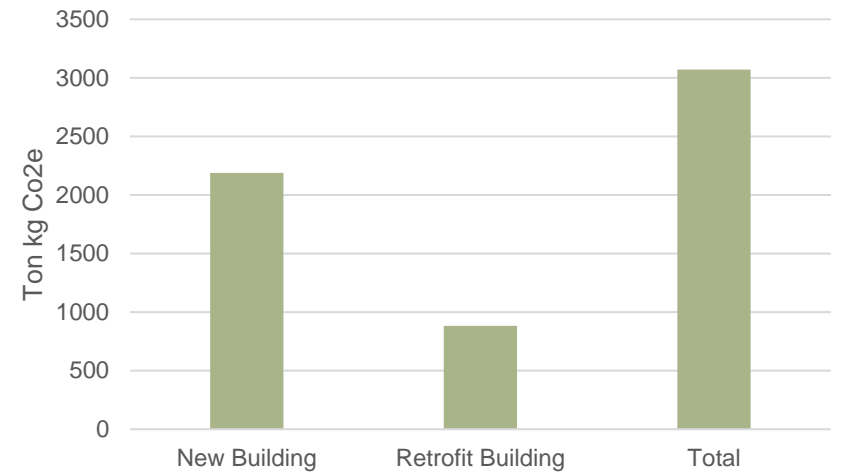
Life-cycle assessment, EN-15978 in Energy use

Life-cycle stage:

Global warming kg CO₂e - Life-cycle stages

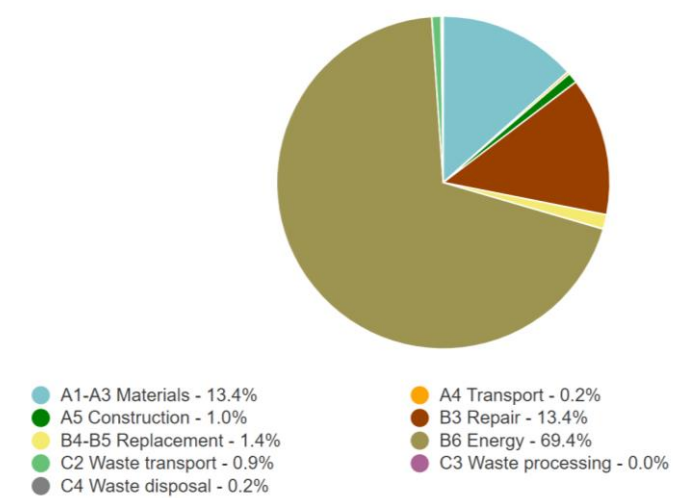


New building



Net Carbon kg CO₂e

Global warming kg CO₂e - Life-cycle stages



Existing building

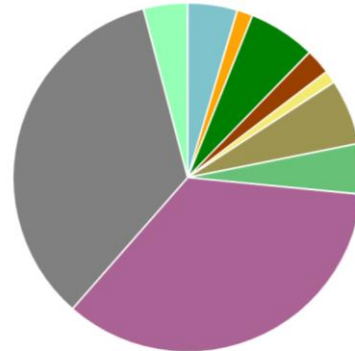


- 1 - - - - -
- 2 - - - - -
- 3 - - - - -
- 4 - - - - -
- 5 - - - - -
- 5.1 - - - - -
- 5.2 - - - - -
- 5.3 - - - - -
- 5.4 - - - - -
- 5.5 - - - - -
- 5.6 - - - - -
- 5.7 - - - - -
- 5.8 - - - - -
- 5.9 - - - - -

- Introducing the team
- Design goals
- Software
- Site context
- Project Highlights:
- Architecture
- Engineering
- Envelope
- Efficiency
- Grid-Interactivity
- Life-Cycle**
- Health
- Market
- Community

How did we calculate the life-cycle emission?

Global warming kg CO₂e - Classifications



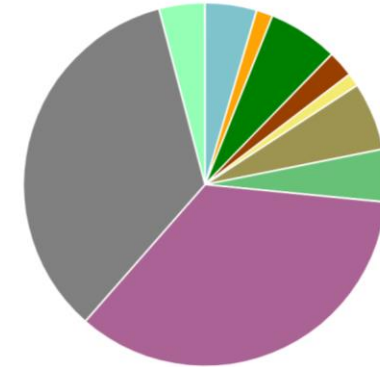
- 1.1 Foundations (substructure) - 4.6%
- 1.2 Facades - 6.2%
- 2.2 In-built lighting system - 1.2%
- 2.4.1 Air handling units - 4.7%
- Electricity use - 34.5%
- 1.3.3 Stairs and ramps - 1.5%
- 1.4.2 Façade openings - 2.3%
- 2.3 Energy system - 6.1%
- Fuel use - 34.9%
- Other classifications - 4.1%

New building

Cradle to grave (A1-A4, B4-B5, C1-C4)	kg CO ₂ e/m ²	
(< 370) A		294
(370-460) B		
(460-550) C		
(550-640) D		
(640-730) E		
(730-820) F		
(> 820) G		

New Buildings Embodied Carbon Emission Benchmark

Global warming kg CO₂e - Classifications



- 1.1 Foundations (substructure) - 4.6%
- 1.2 Facades - 6.2%
- 2.2 In-built lighting system - 1.2%
- 2.4.1 Air handling units - 4.7%
- Electricity use - 34.5%
- 1.3.3 Stairs and ramps - 1.5%
- 1.4.2 Façade openings - 2.3%
- 2.3 Energy system - 6.1%
- Fuel use - 34.9%
- Other classifications - 4.1%

Existing building

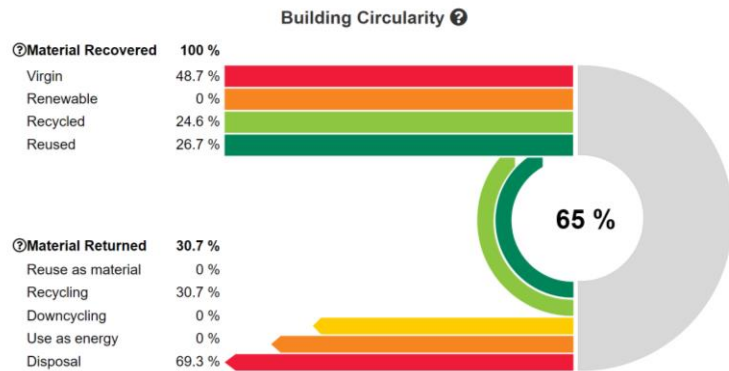
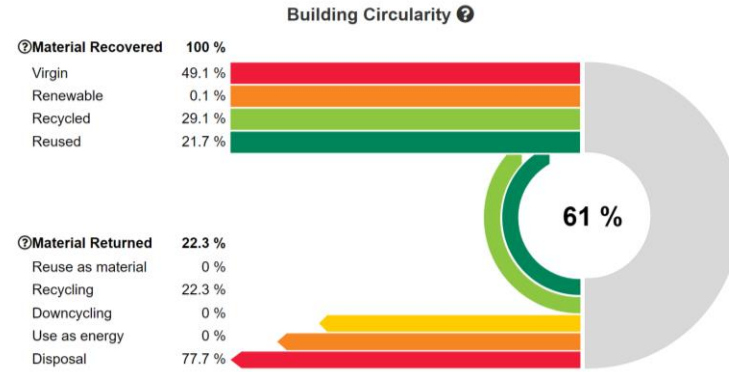
Cradle to grave (A1-A4, B4-B5, C1-C4)	kg CO ₂ e/m ²	
(< 370) A		190
(370-460) B		
(460-550) C		
(550-640) D		
(640-730) E		
(730-820) F		
(> 820) G		

Retrofitted Buildings Embodied Carbon Emission Benchmark

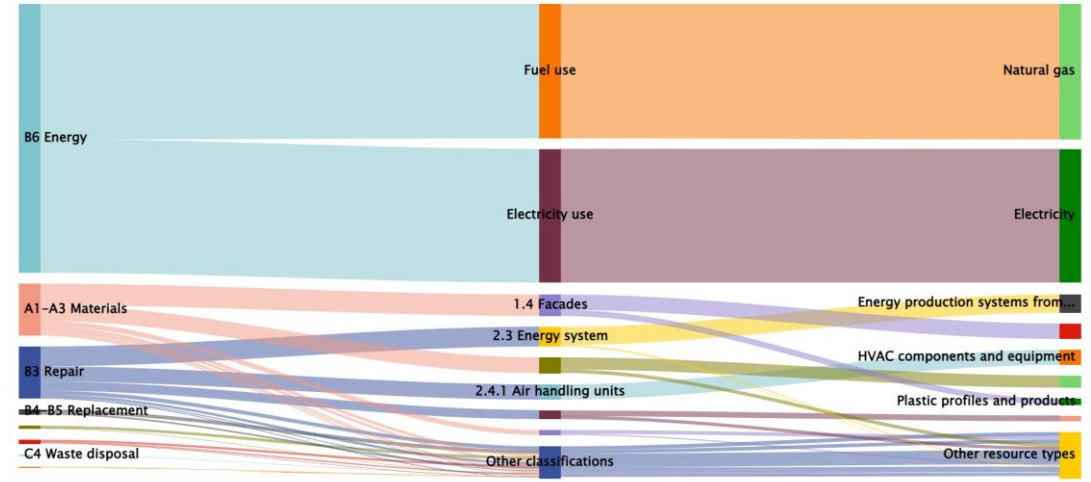


- 1 --- Introducing the team
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- 5.3 --- Envelope
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- 5.5 --- Grid-Interactivity
- 5.6 --- Life-Cycle
- 5.7 --- Health
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How did we calculate the building's circularity?

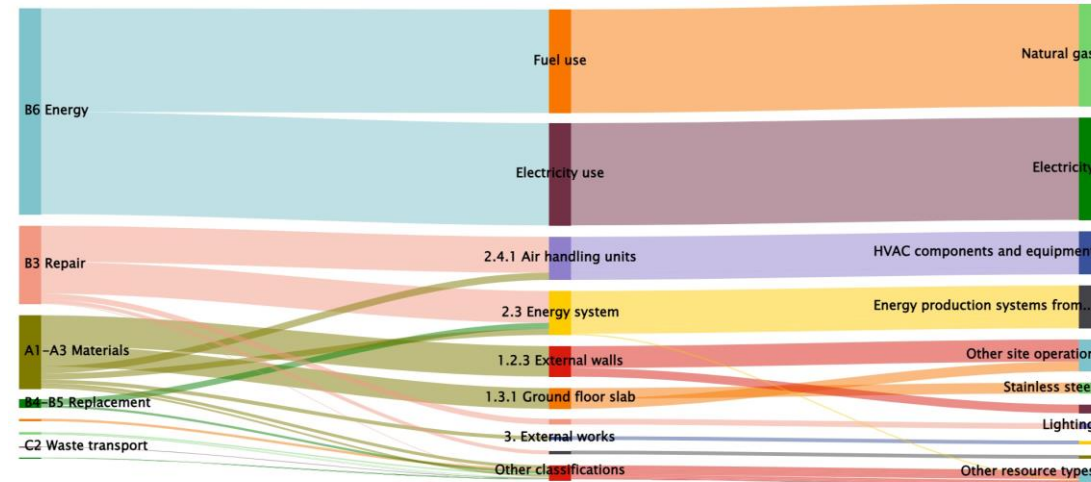


Sankey diagram, Global warming



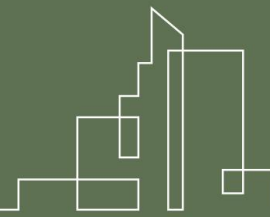
New building

Sankey diagram, Global warming



Retrofit building

5.7

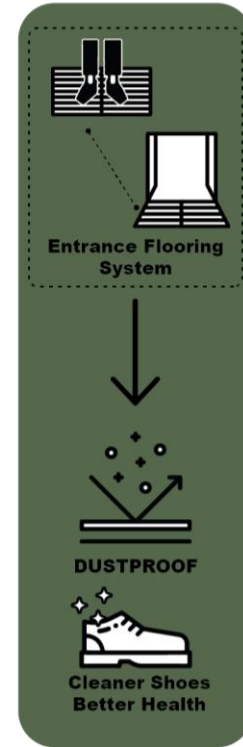
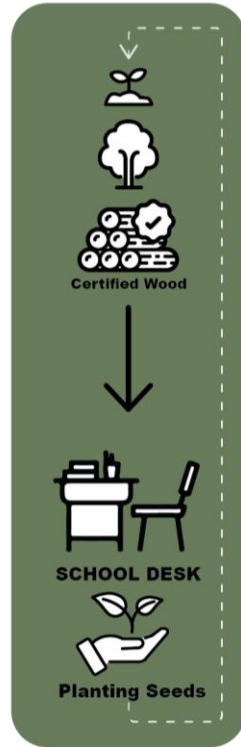
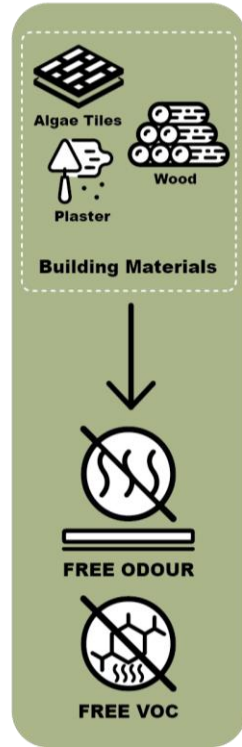
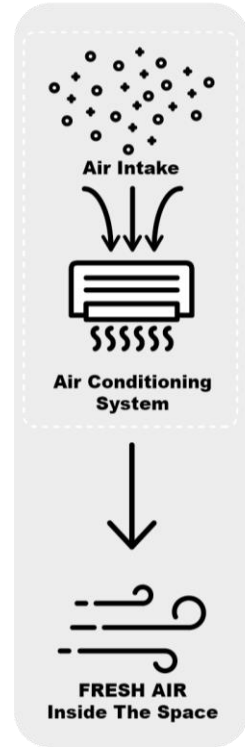


Health

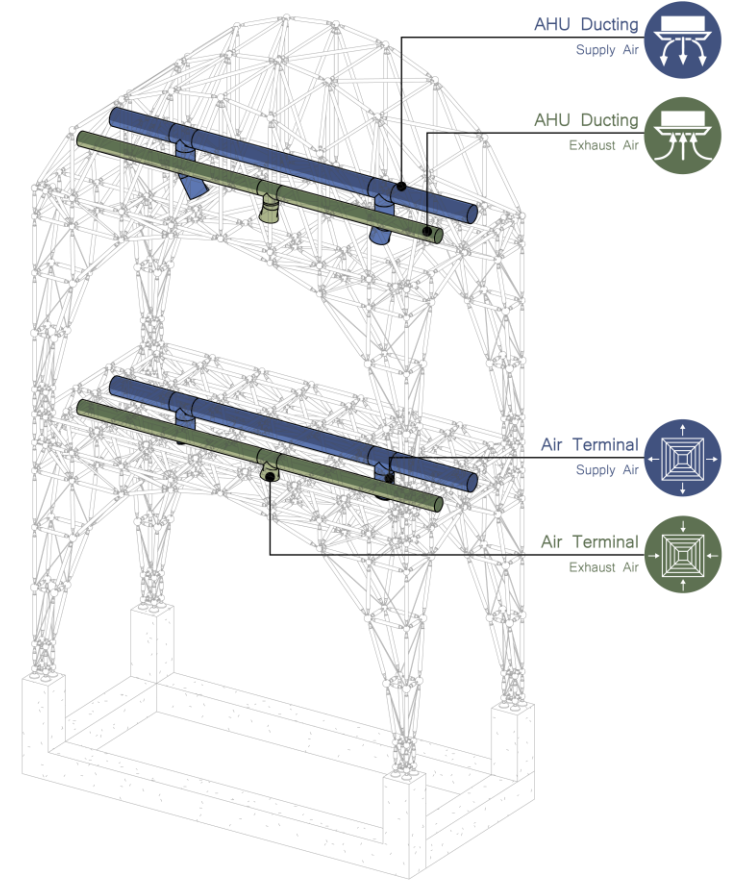


How would we improve the inhabitant's health?

- 1 --- Introducing the team
- 2 --- Design goals
- 3 --- Software
- 4 --- Site context
- 5 --- Project Highlights:
 - 5.1 --- Architecture
 - 5.2 --- Engineering
 - 5.3 --- Envelope
 - 5.4 --- Efficiency
 - 5.5 --- Grid-Interactivity
 - 5.6 --- Life-Cycle
 - 5.7 **Health**
 - 5.8 --- Market
 - 5.9 --- Community



Health and Emissions of Materials and Systems:



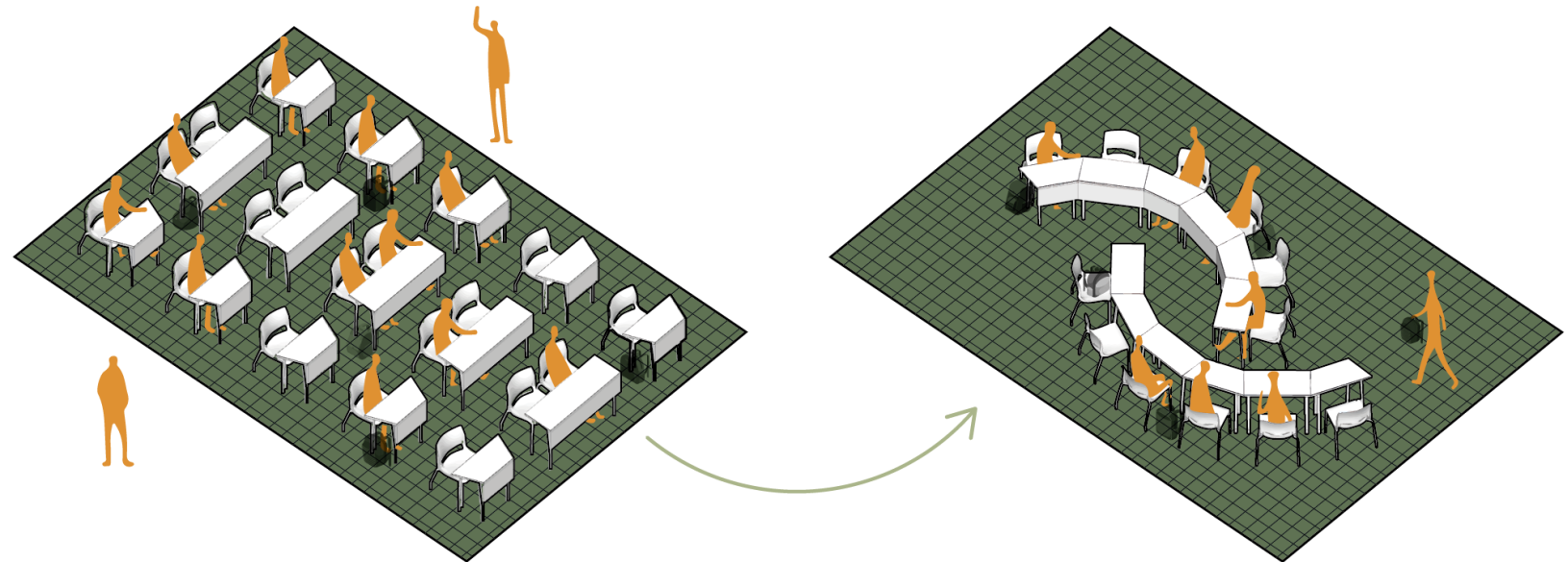
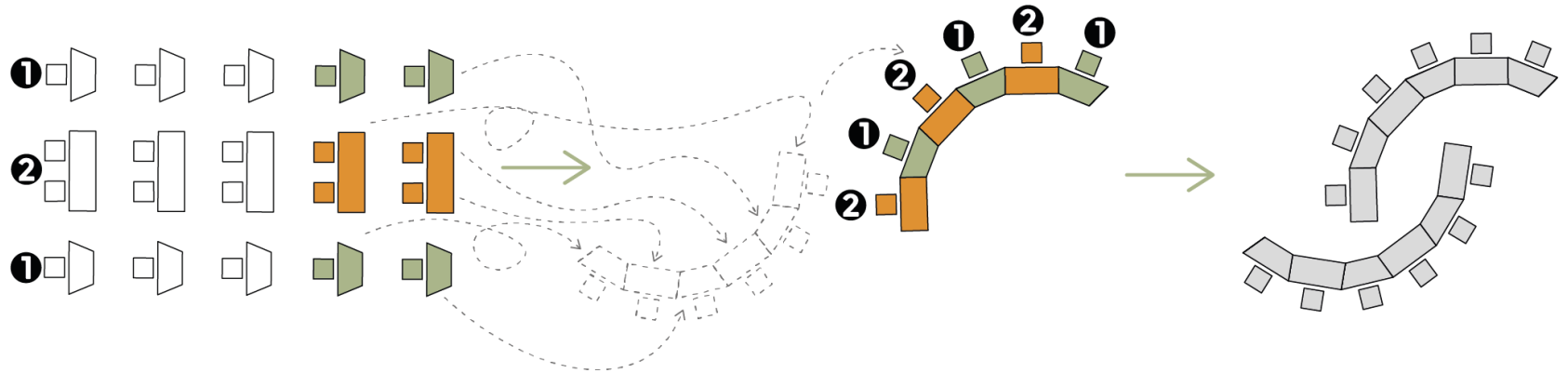
AHU Supply and Return Ducts



- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
 - 5.1 - - - - - Architecture
 - 5.2 - - - - - Engineering
 - 5.3 - - - - - Envelope
 - 5.4 - - - - - Efficiency
 - 5.5 - - - - - Grid-Interactivity
 - 5.6 - - - - - Life-Cycle
 - 5.7 - - - - - **Health**
 - 5.8 - - - - - Market
 - 5.9 - - - - - Community

Why have we **design flexible furniture**?

Classroom desks are designed in a way to accommodate different arrangements for flexible usage.

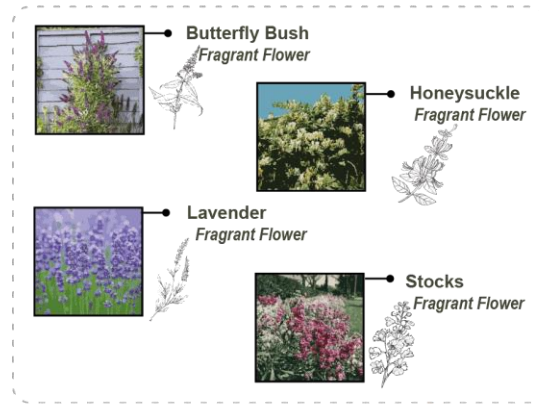




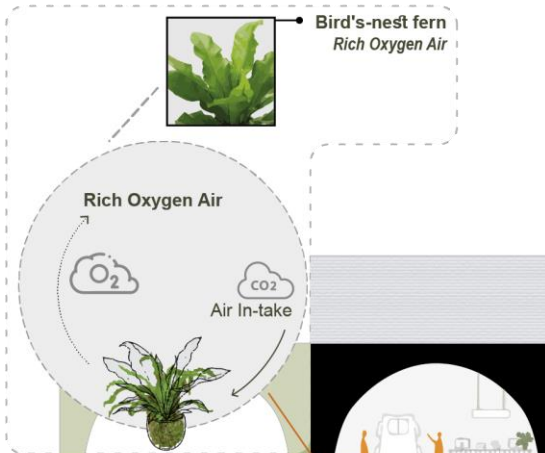
How would we improve the inhabitant's health with green walls?

- 1 - Introducing the team
- 2 - Design goals
- 3 - Software
- 4 - Site context
- 5 - Project Highlights:
 - 5.1 - Architecture
 - 5.2 - Engineering
 - 5.3 - Envelope
 - 5.4 - Efficiency
 - 5.5 - Grid-Interactivity
 - 5.6 - Life-Cycle
 - 5.7 - Health
 - 5.8 - Market
 - 5.9 - Community

Vegetation: Fragrant Flowers:



Oxygen-producing Plant:



Classroom's Green wall

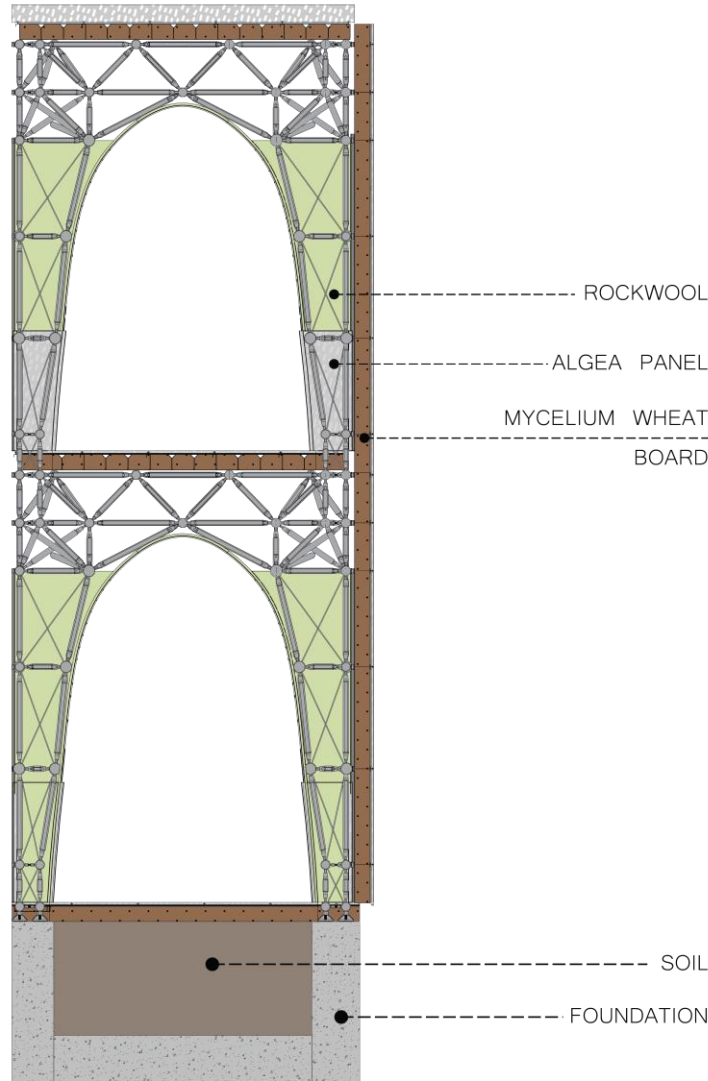


Workshop's Green wall



How did we control the noise?

- 1 - Introducing the team
- 2 - Design goals
- 3 - Software
- 4 - Site context
- 5 - Project Highlights:
 - 5.1 - Architecture
 - 5.2 - Engineering
 - 5.3 - Envelope
 - 5.4 - Efficiency
 - 5.5 - Grid-Interactivity
 - 5.6 - Life-Cycle
 - 5.7 - Health
 - 5.8 - Market
 - 5.9 - Community



R_w According to the Position of the Dividing Walls

		Calculated R _w (dB)	R _w (dB) according to national building regulations of Iran(topic 18)
External wall	Classroom	43	40
	Workshop	44	45
	Office	44	40
	Library	42.9	40
Internal wall	Between offices	62	45
	classrooms and workshops from adjacent spaces	62	50
	classroom and corridor	36-55	35
	facility spaces and other adjacent spaces	62	55

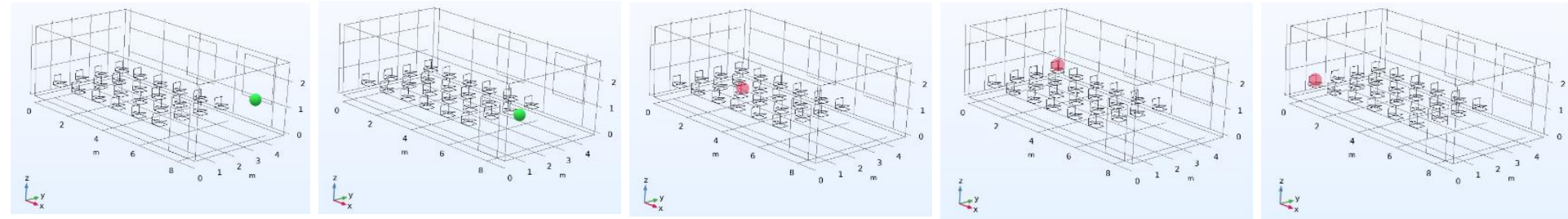
L_{nw} According to the Position of the ceiling

Floor Position	Calculated L _{nw} (dB)	L _{nw} (dB) according to national building regulations of Iran(topic 18)
Floor between classrooms	58	60
Floor between corridors	58	62
Office ceiling	58	65



- 1 - - - - - Introducing the team
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- 5.4 - - - - - Efficiency
- 5.5 - - - - - Grid-Interactivity
- 5.6 - - - - - Life-Cycle
- 5.7 - - - - - **Health**
- 5.8 - - - - - Market
- 5.9 - - - - - Community

How did we control the reverberation time?



Sound sources positions Sound sources positions Receiver positions Receiver positions Receiver positions

Reverberation Time and the area of required Mycelium-Based Sound Absorption Panels for acoustic treatment

Space Type	Reverberation Time in Octave Band Center Frequencies						RT ₆₀ (s) averaged reverberation time	RT ₆₀ (s) according to national building regulations of Iran(topic 18)	area of Mycelium-Based Sound Absorption Panels (m ²)
	125	250	500	1000	2000	4000			
Classroom	0.98	0.90	0.89	0.91	0.82	0.78	0.87	1.0	Not Required
Workshop	0.97	1.04	1.42	1.87	1.62	1.30	1.63	1.0-1.2	23.6
Office	0.63	0.66	0.94	1.20	1.07	0.86	1.07	1.2	Not Required
Multifunctional space	0.99	0.92	1.07	1.20	1.26	1.24	1.17	0.8-0.9	68
Library	1.10	1.13	1.14	1.23	1.08	0.99	1.15	0.7	51
Prayer Room	1.11	1.07	1.17	0.69	0.56	0.54	0.80	0.8-0.9	Not Required

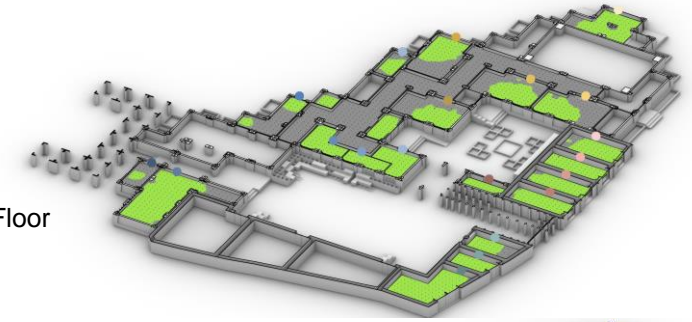


- 1 - - - - - Introducing the team
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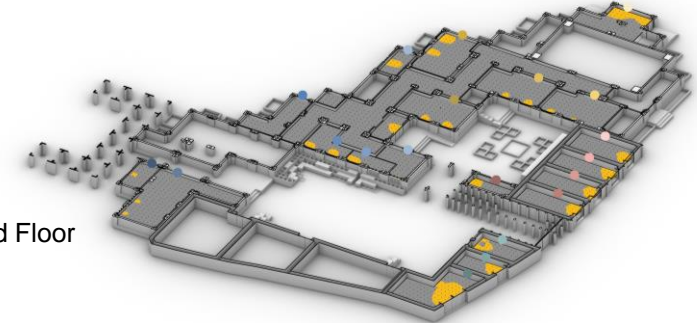
Daylight improvements:

Space	sDA (%)	ASE (%)	DGP (%)	UDI (%)
Regular Classroom	57.02	4.96	5.99	49.17
Regular Classroom	76.03	5.79	5.68	55.48
Regular Classroom	62.07	5.17	6.25	48.08
Flexible Classroom	52.14	8.55	7.59	45.18
Student product shop	86.17	22.34	32.95	62.80
Office	62.86	17.14	12.14	58.37
Office	100	3.57	23.44	84.67
Office	100	17.5	37.69	79.64
Office	100	16.55	28.80	75.93
Office	38.70	0.00	1.51	32.50
Buffet	100	17.90	45.19	80.30
Buffet	88.36	1.29	7.11	68.32
Janitor	66.13	16.13	19.56	62.03
Bakery	92.31	10.90	22.94	69.40
Pottery shop	97.44	11.54	33.49	74.35
Stationary shop	89.74	11.54	34.62	70.33
Fabric shop	78.21	12.82	33.49	73.05
Super market	100	26.60	56.11	73.64
Persian restaurant	97.48	32.70	59.78	72.61
Waste management room	18.60	4.65	5.80	32.15
Overall Result	61.7%	8.8%	18%	63.4%

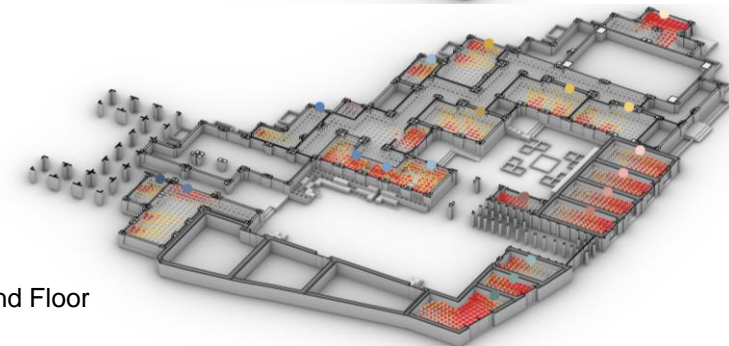
Ground Floor



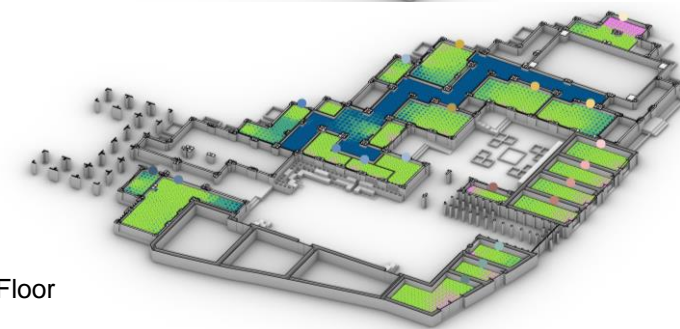
sDA, Ground Floor



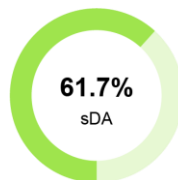
ASE, Ground Floor



DGP, Ground Floor



UDI, Ground Floor

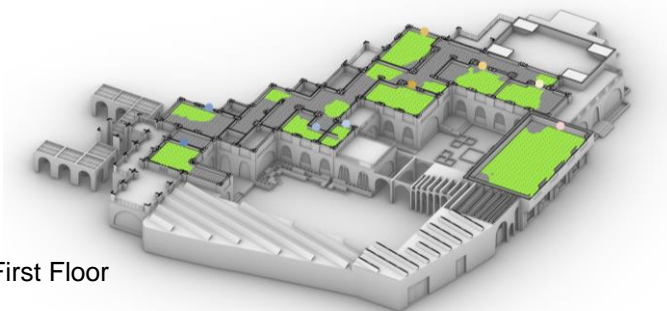
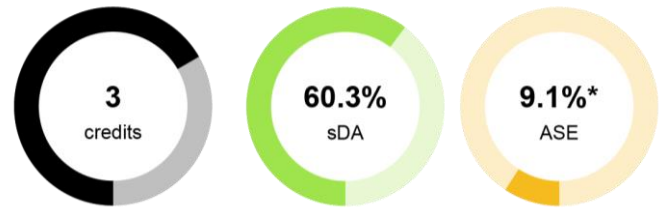




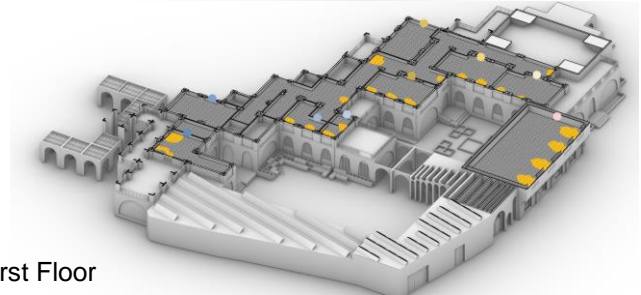
- 1 - Introducing the team
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Daylight improvements:

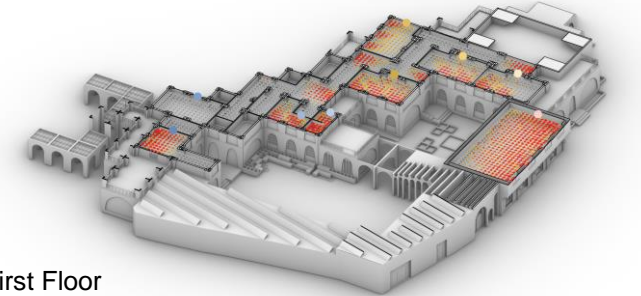
	Space Name	sDA (%)	ASE (%)	DGP(%)	UDI (%)
First Floor	Regular Classroom	65.45	8.18	9.43	57.27
	Regular Classroom	66.67	9.65	9.65	54.15
	Regular Classroom	100	15.93	21.90	70.46
	Flexible Classroom	85.96	2.63	6.14	67.55
	Book Café	92.98	13.78	30.98	69.44
	Office	91.67	28	47.92	65.97
	Office	88.14	20.34	26.48	65.65
	Prayer room	32.23	0.00	0.10	29.24
Second Floor	Library office	74.29	19.05	26.90	64.60
	Overall Result	60.3 %	9.1 %	16.3 %	60.48 %
	Library salon	73.89	7.01	12.42	67.60
	Reading room	38.62	2.76	7.07	60.87
	Overall Result	46.6 %	6.9 %	10.2 %	64.7 %



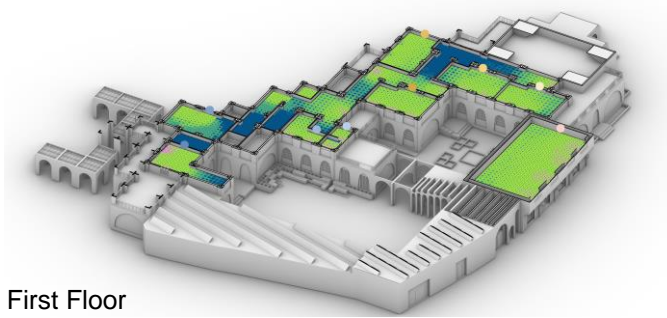
sDA, First Floor



ASE, First Floor



DGP, First Floor



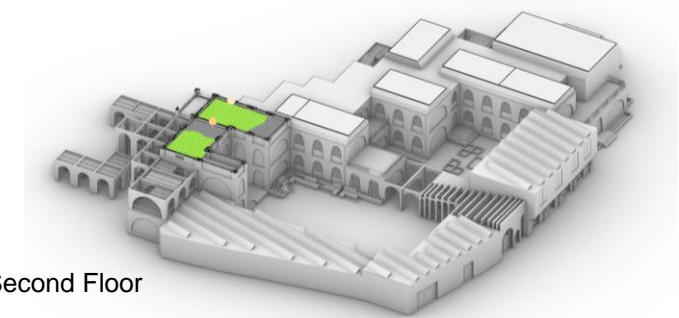
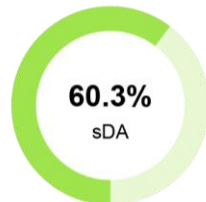
UDI, First Floor



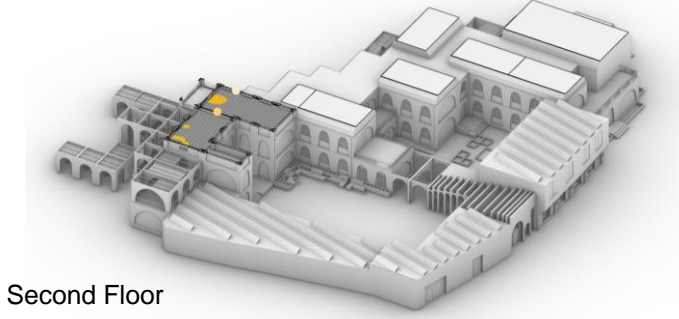
- 1 - Introducing the team
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Daylight improvements:

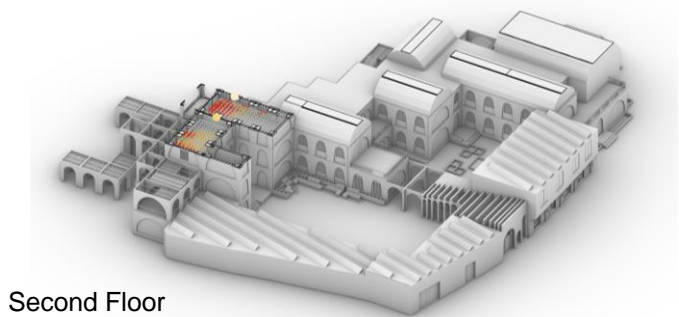
	Space Name	sDA (%)	ASE (%)	DGP(%)	UDI (%)
First Floor	Regular Classroom	65.45	8.18	9.43	57.27
	Regular Classroom	66.67	9.65	9.65	54.15
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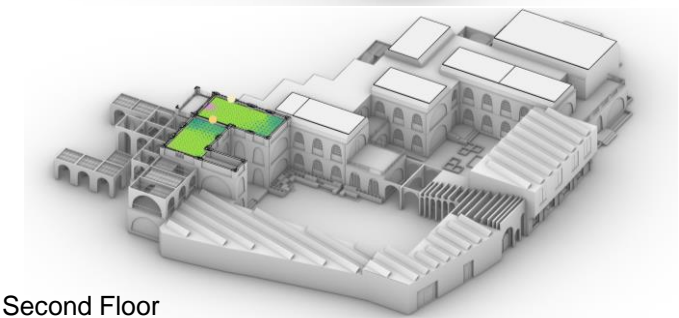
sDA, Second Floor



ASE, Second Floor



DGP, Second Floor

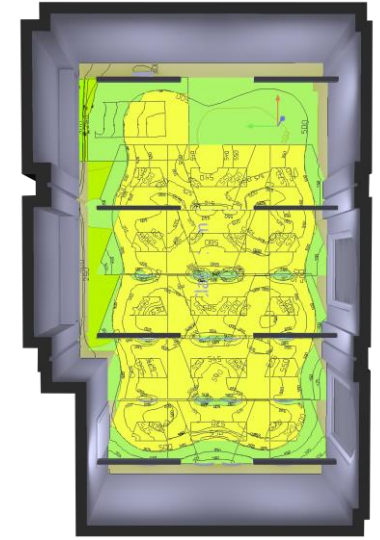
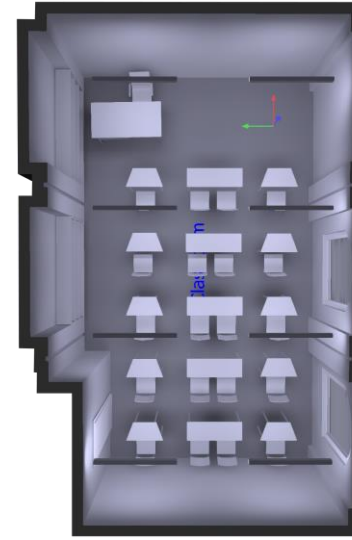
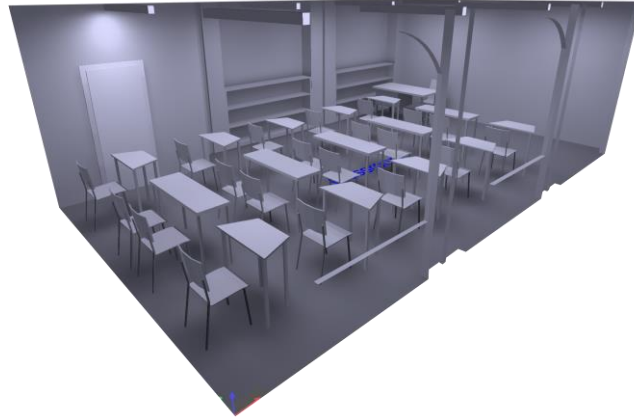


UDI, Second Floor

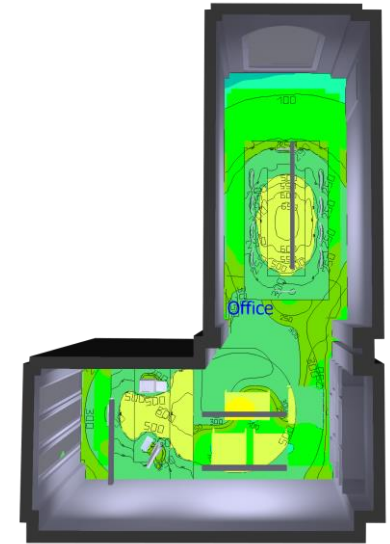
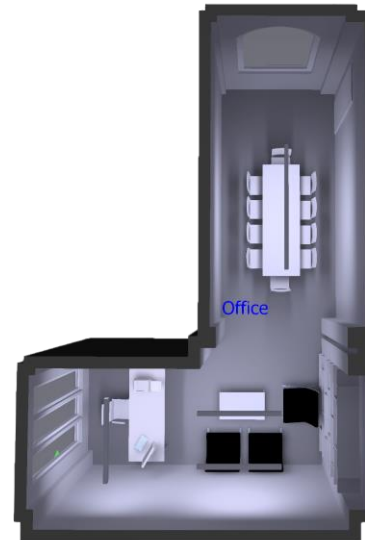
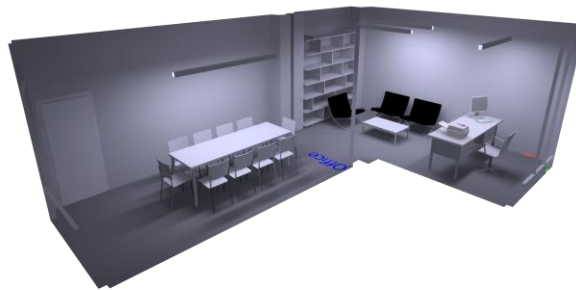


- 1 - - - - - Introducing the team
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Classroom's Artificial light improvements:



Office's Artificial light improvements:



5.8

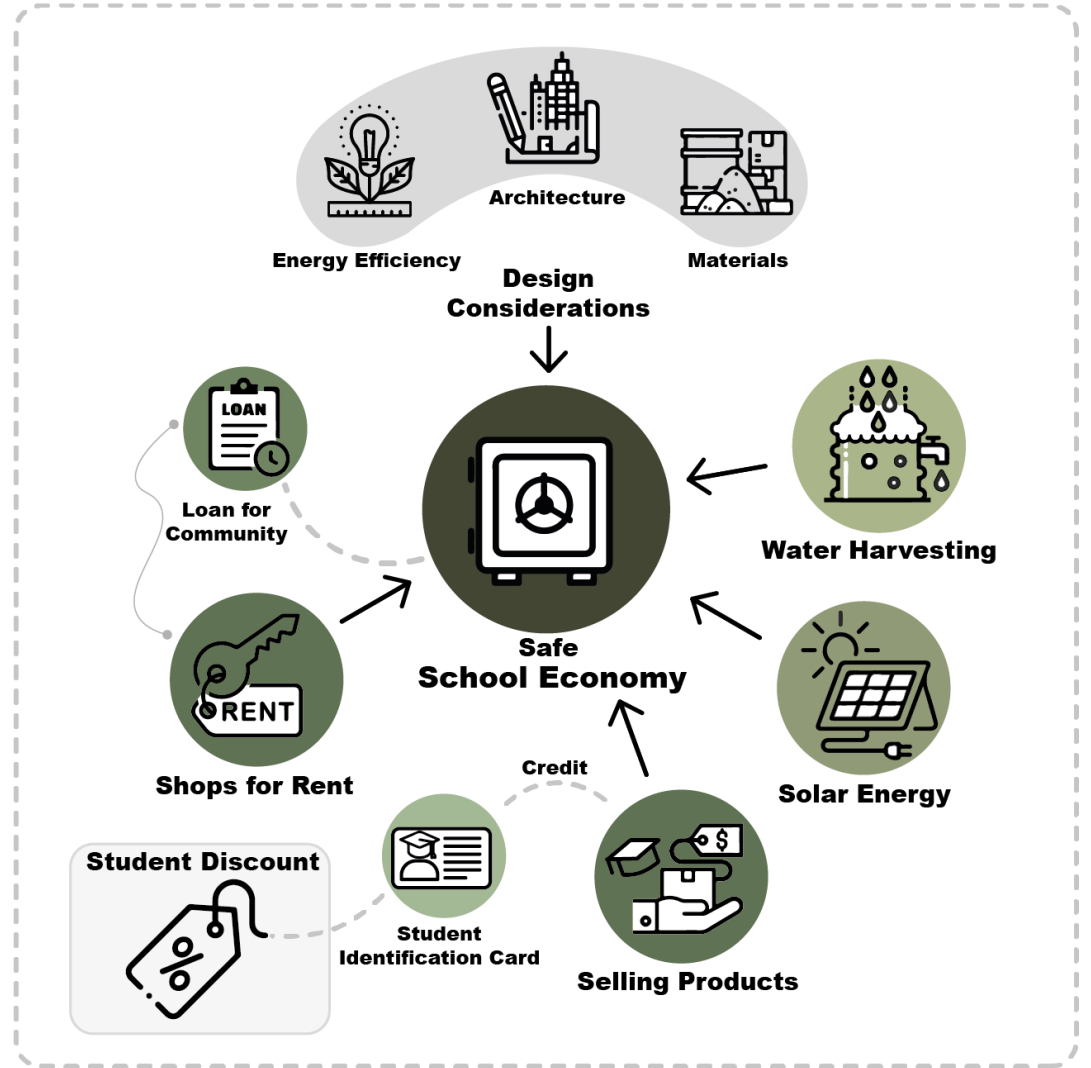
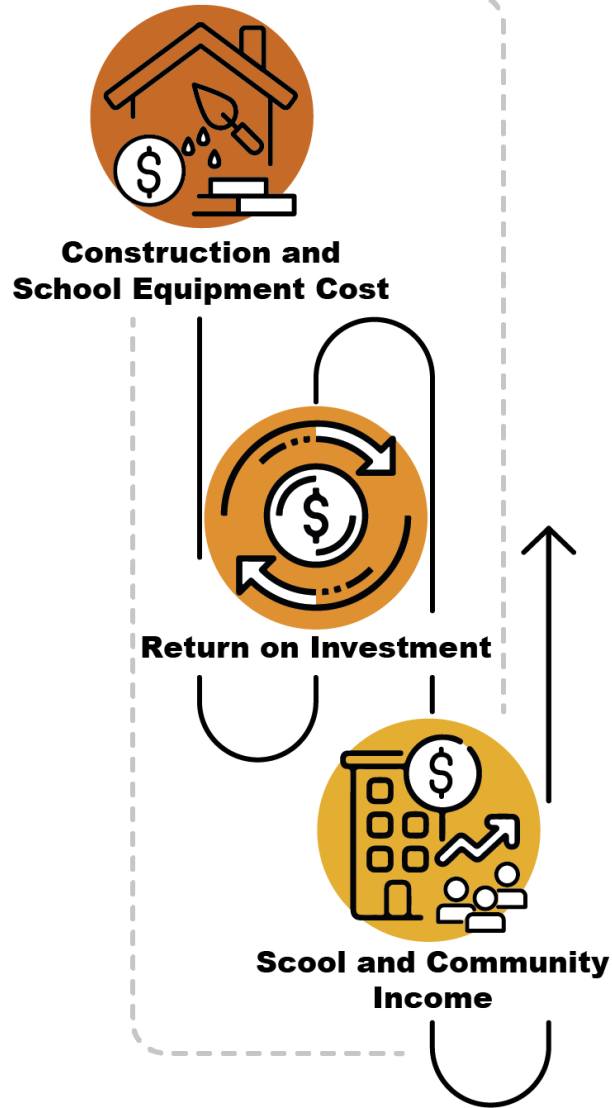


Market



How would we improve the neighborhood's economy?

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 - 5.6 --- Life-Cycle
 - 5.7 --- Health
 - 5.8 --- Market**
 - 5.9 --- Community





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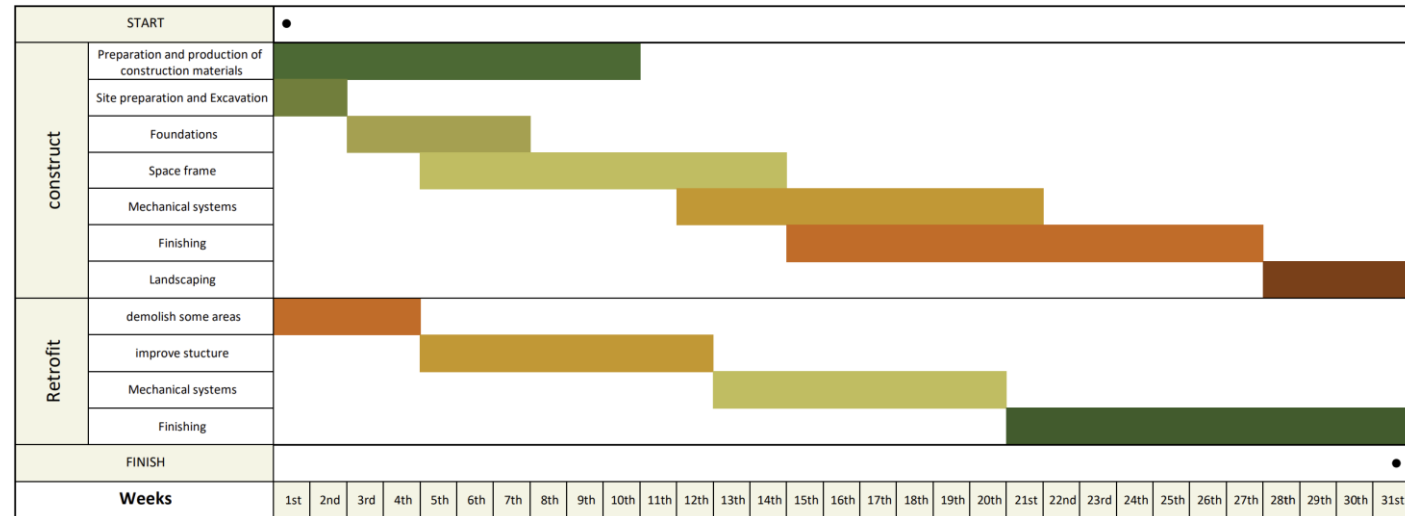
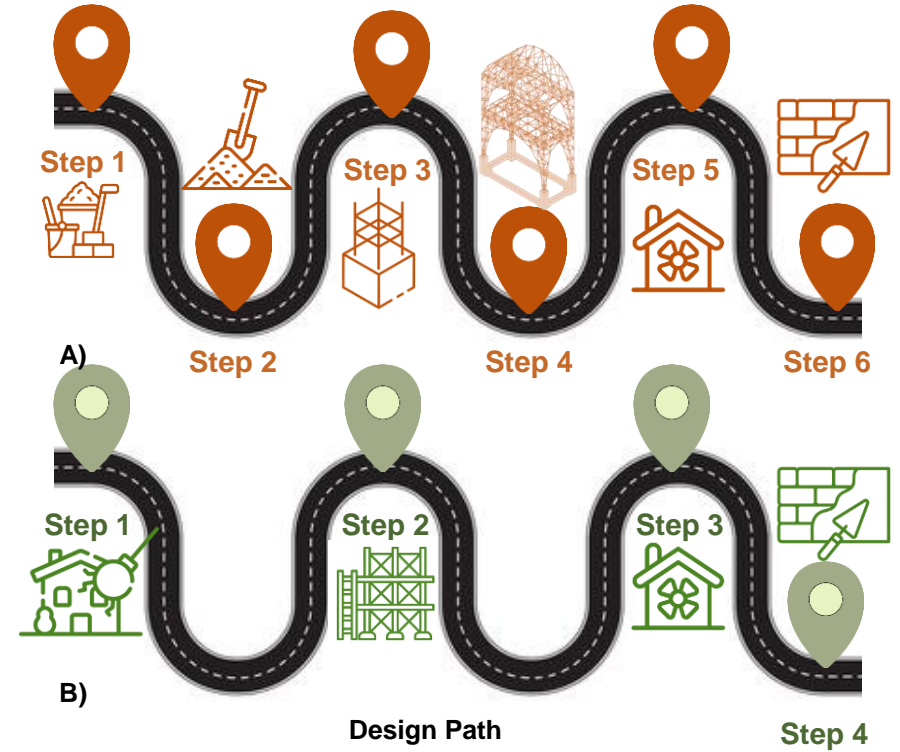
What are our construction process?

• Construction process for each module

1. Preparation and production of construction materials
2. Site preparation and Excavation
3. Foundations
4. Space frame
5. Mechanical systems
6. Finishing

• Construction process for retrofitted a building

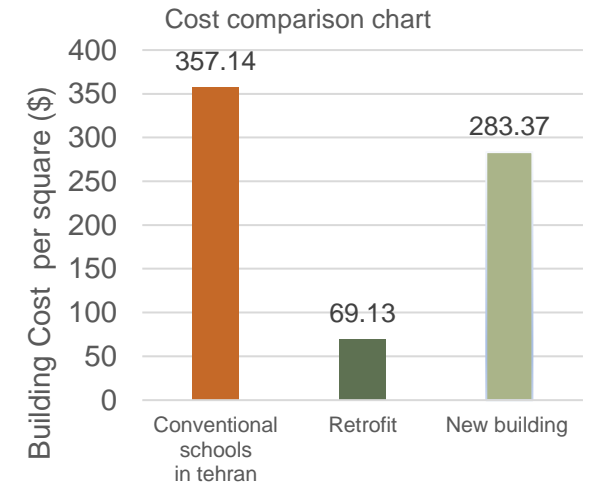
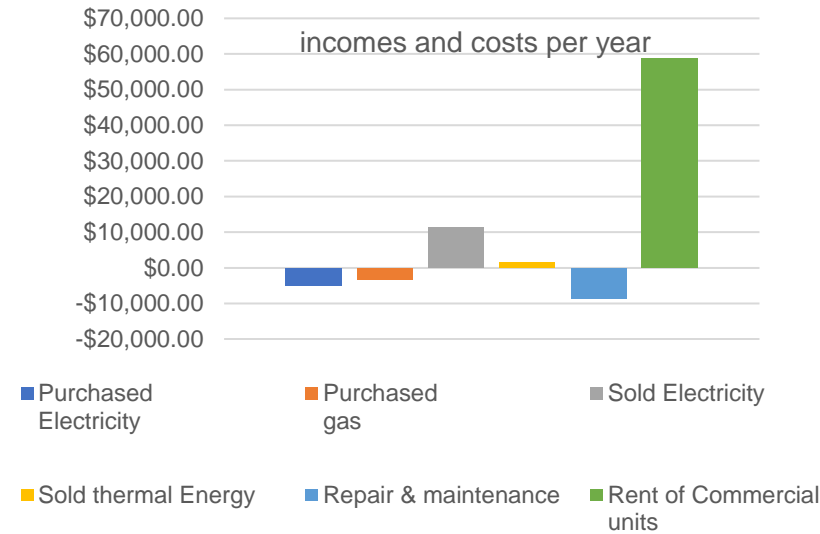
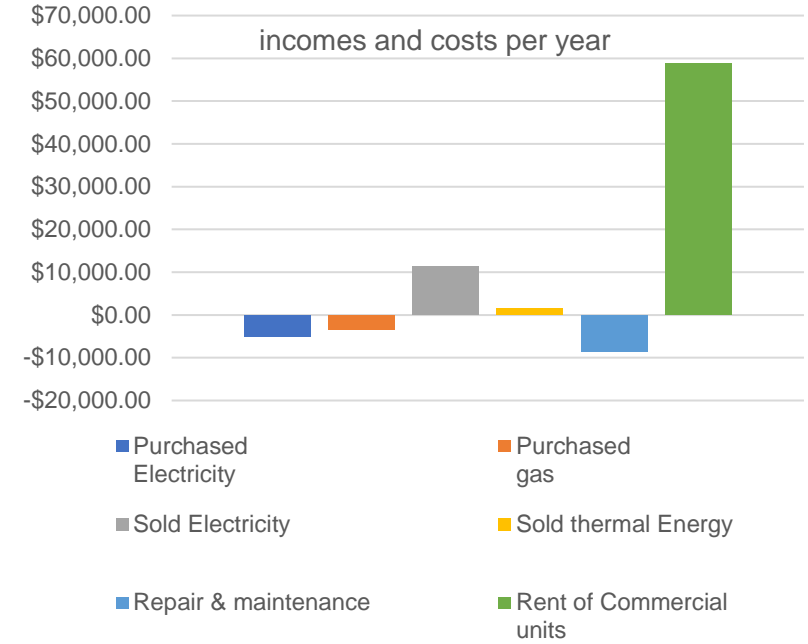
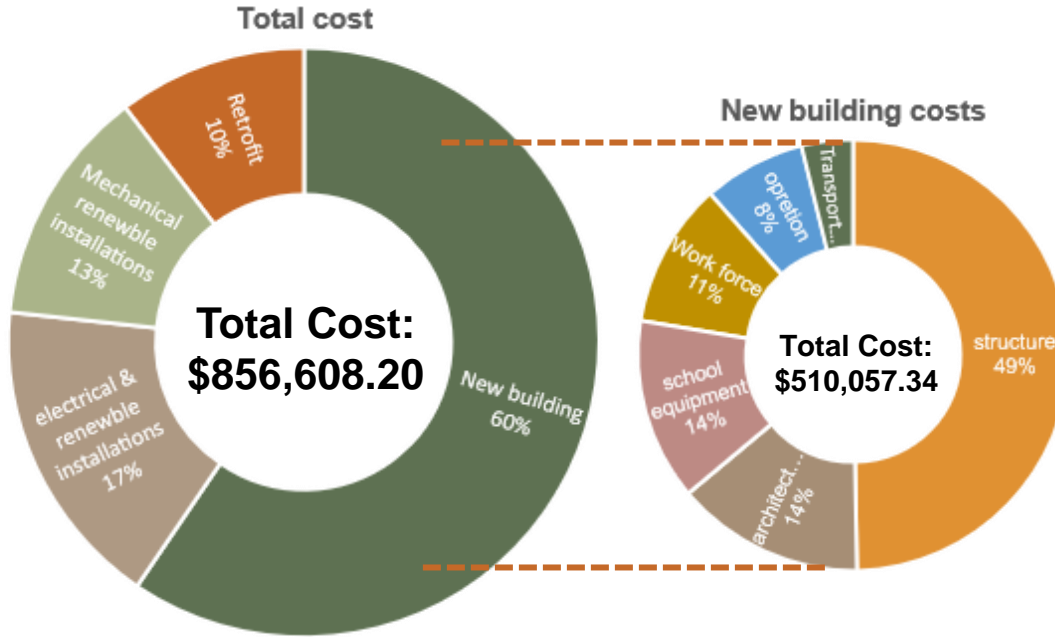
1. demolish some areas
2. improve structure
3. Mechanical systems
4. Finishing





What was the cost calculation process?

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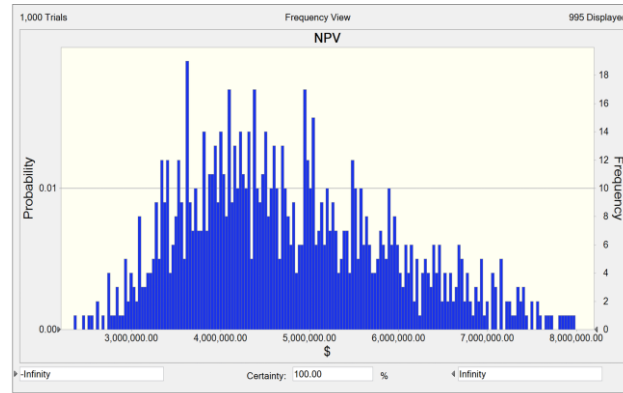


- 1 - - - - - Introducing the team
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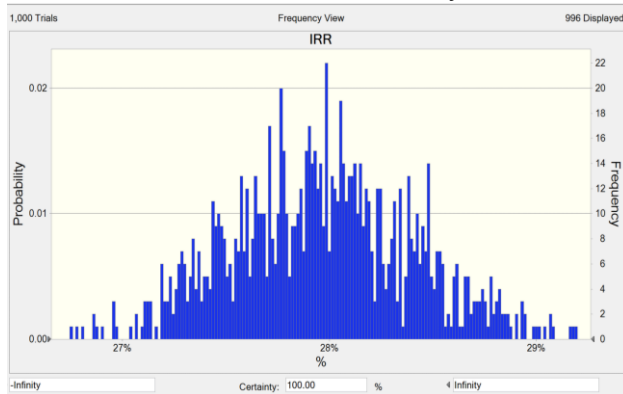
Why did we calculate the **building cost in risk condition**?

calculation results

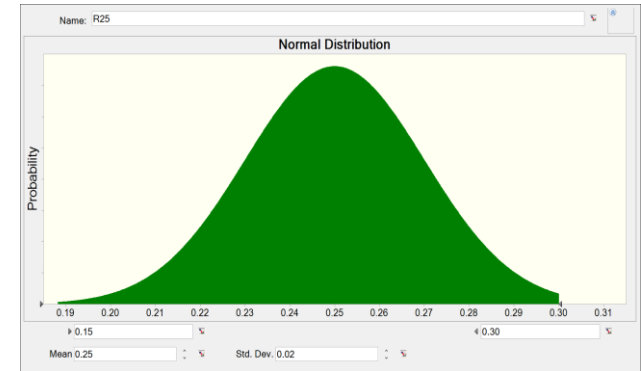
Scenarios	NPV (\$)	IRR (%)	PBT (Year)
1-Certainty	\$2,010,109.69	23%	13
2-Risk	There is a 100% probability that it will be positive in the calculation period of 25 years.	100% probability is greater than 25% in the calculation period of 25 years.	100% PBT is less than 12 years and 2% less than 10 years.



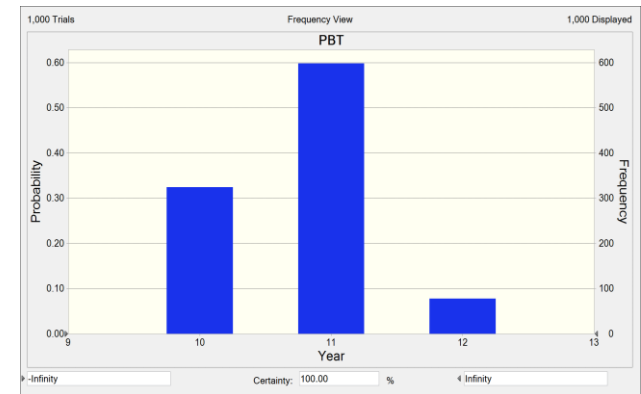
Net Percent Value Analysis



Internal Rate of Return Analysis

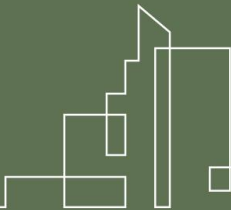


Normal Distribution for Rent of Commercial Units



Pay Back Time Analysis

5.9

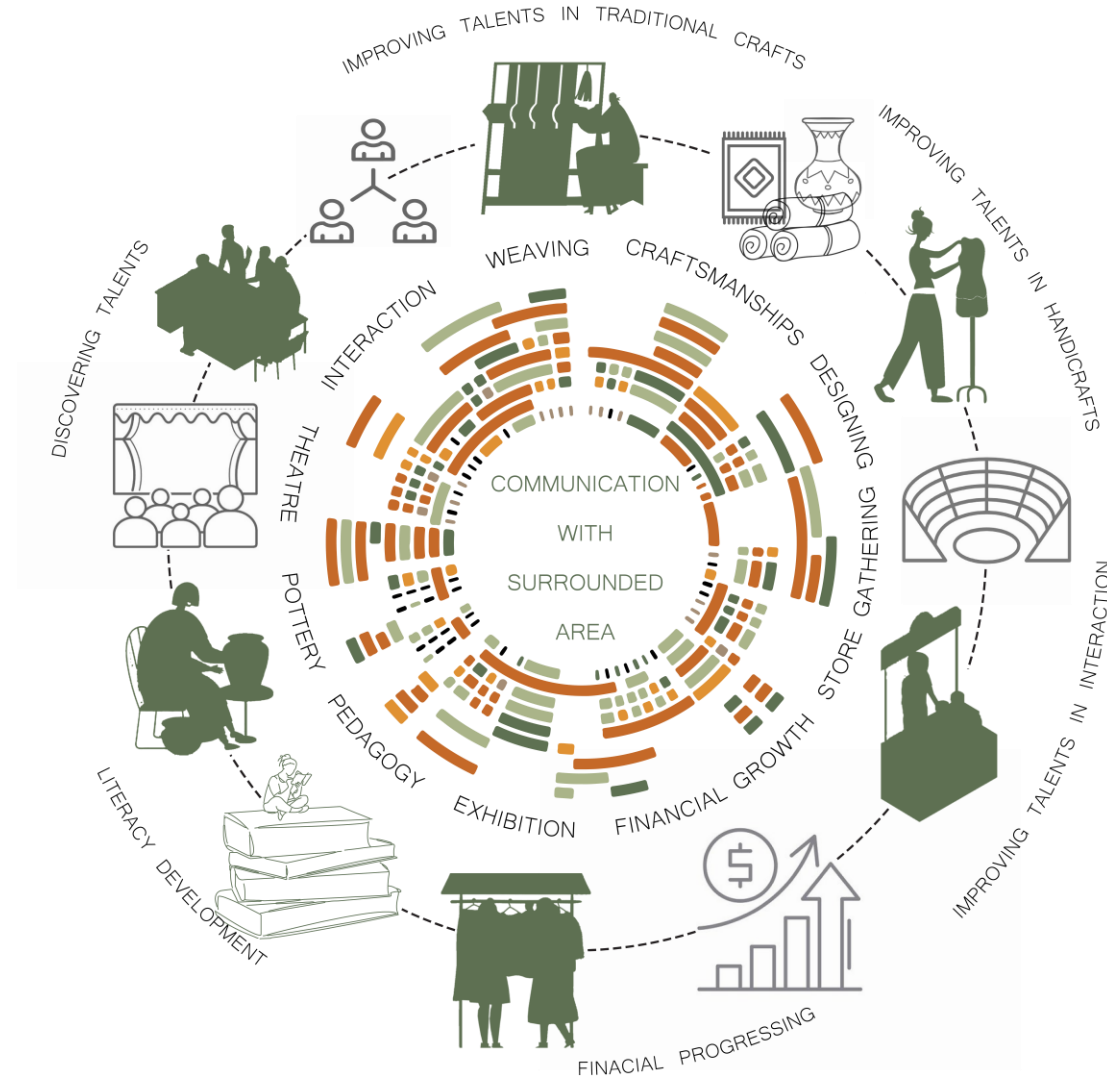


Community



How does the school **interact** with the **neighborhood**?

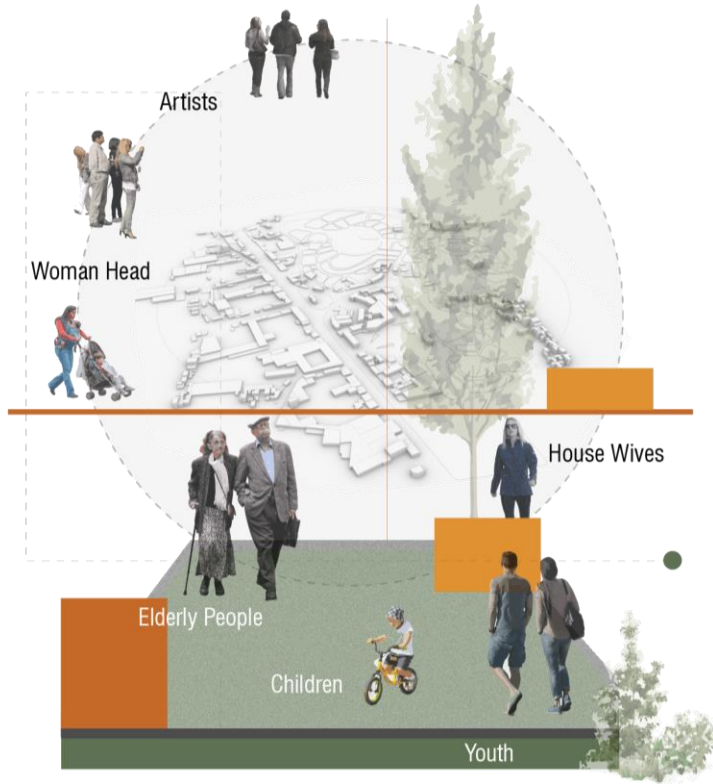
- 1 --- Introducing the team
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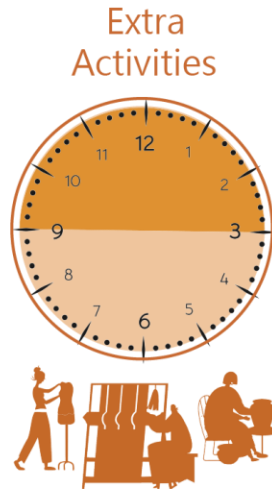
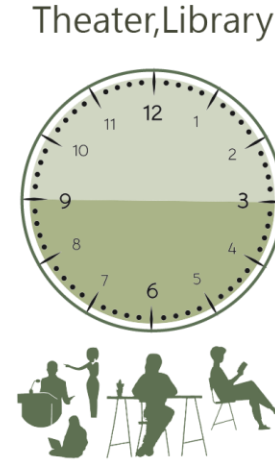
School as a neighborhood center





At what times do the students and neighborhoods can use the school?

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- 3 - - - - - Software
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- 5.9 Community

How does the school *interact* with the *neighborhood*?



Secure Connection with the park

Crime Reduction

reduce the dangerous atmosphere in the park





- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
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- 5.9 Community

How does the school *interact* with the *neighborhood*?

change the function of the big storage place into book cafe

Improve public culture

enhance society's consciousness

revive the urban walls(landscape)

encourage nightlife

The library is used by the students and neighborhood inhabitants

longer Working Hours after school time

Encouragement to read book

Boost public culture





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How does the school **interact** with the **neighborhood**?

change the interior design of the old canteen

make the place suitable for women and families

Improve nightlife in this area

Teach skills to girl students

become accustomed to Persian art and culture

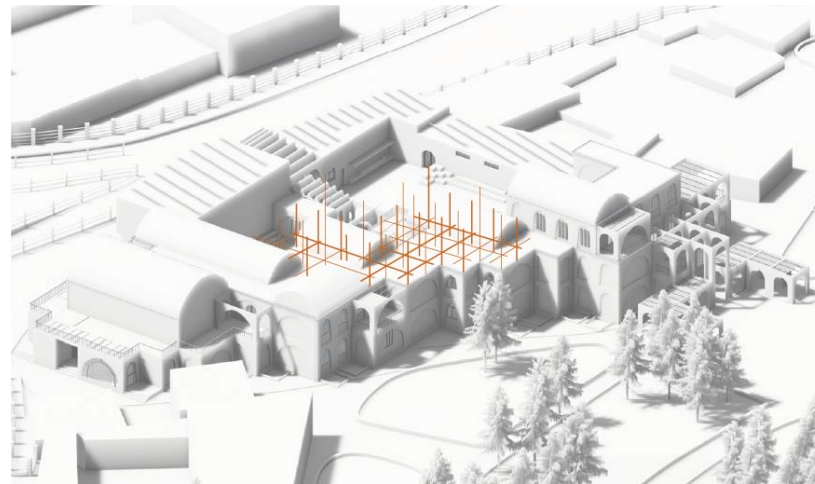
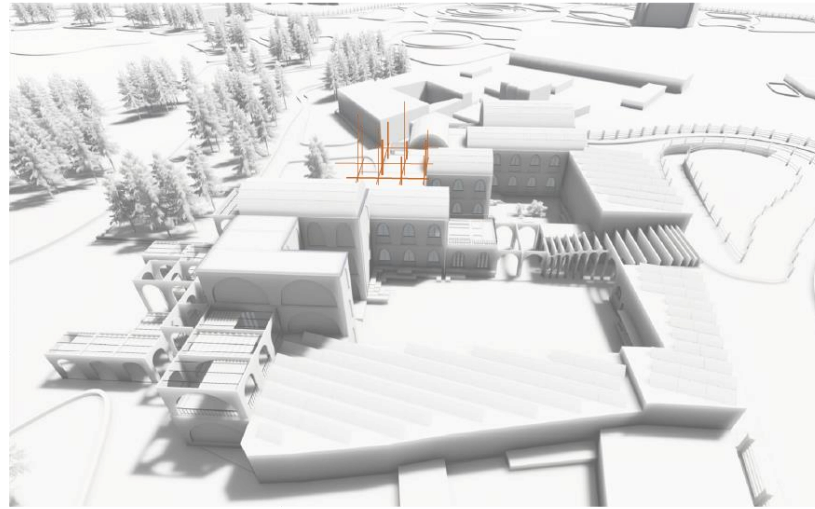
teach how to make money from skills and arts





How does the school **expand**?

- 1 - - - - - Introducing the team
- 2 - - - - - Design goals
- 3 - - - - - Software
- 4 - - - - - Site context
- 5 - - - - - Project Highlights:
 - 5.1 - - - - - Architecture
 - 5.2 - - - - - Engineering
 - 5.3 - - - - - Envelope
 - 5.4 - - - - - Efficiency
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 - 5.9 - - - - - **Community**




● Availability of vertical expansion

● Availability of horizontal expansion

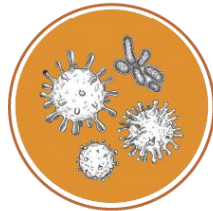


How does the school help people in critical situations?

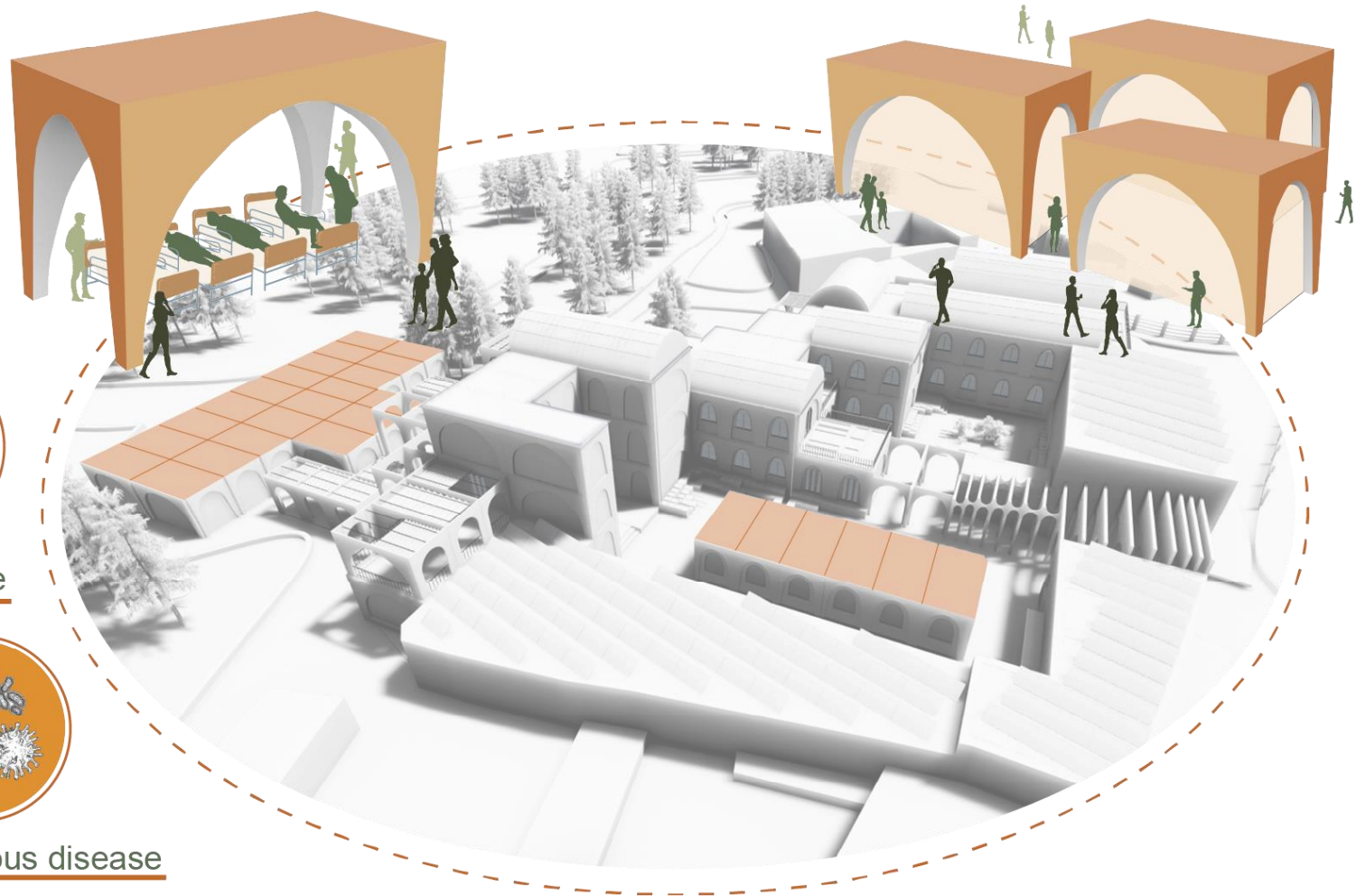
- 1 - - - - - Introducing the team
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 - 5.3 - - - - - Envelope
 - 5.4 - - - - - Efficiency
 - 5.5 - - - - - Grid-Interactivity
 - 5.6 - - - - - Life-Cycle
 - 5.7 - - - - - Health
 - 5.8 - - - - - Market
 - 5.9  - - - - - Community



Earth quake



Infectious disease

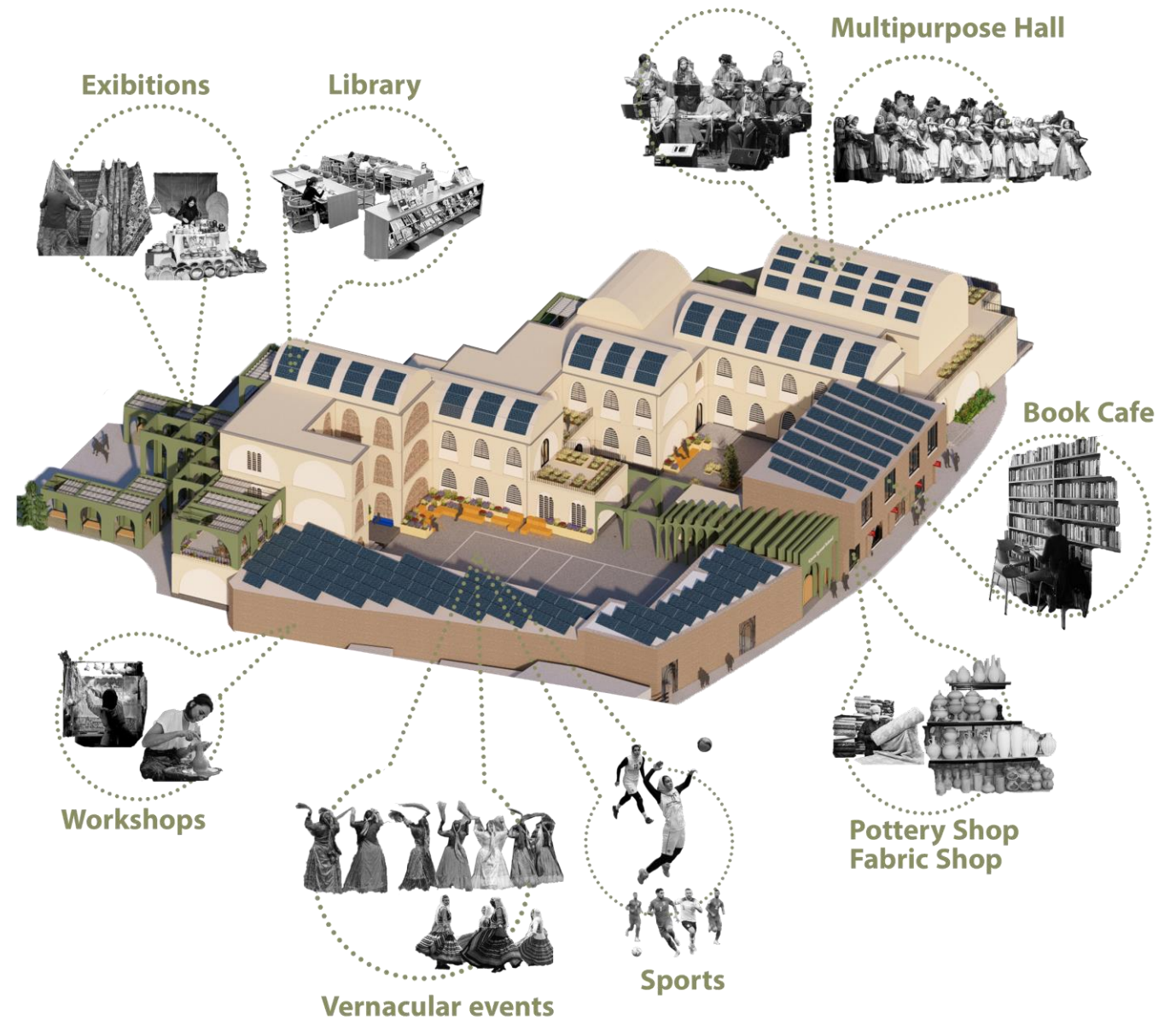


● The possibility of quick construction of modules for settling people in critical situations.

Tehran University of Art | The Green Sprout School Highlights

Design Goals

- Water & energy management
- Multifunctional and flexible space
- Minimizing embodied carbon & energy
- Using innovative materials
- Revival of Ancient Architecture
- Community engagement
- Building resilience
- Income Opportunity
- Occupancy Health Improvement



Industry partnership:



THANK YOU

U.S. Department of Energy

Solar Decathlon Organizers

Solar Decathlon Jurors