

Division presentation

Kindergarten in Sangga Village

Team Solar Ark

Southeast University
Tibet University



Architecture

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Energy

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Team Leader

Haochen Xu



Tibet Plateau
AMSL 3000-5000m



Sangga Village, Shannan, Tibet
Autonomous Region , China



Alterations and additions

Misused courtyard building -----> Kindergarten

Target occupant

30 local students /3 classes

10 kindergarten staff

Climate Zone

5C

Lot size

0.695 acre

PROBLEMS

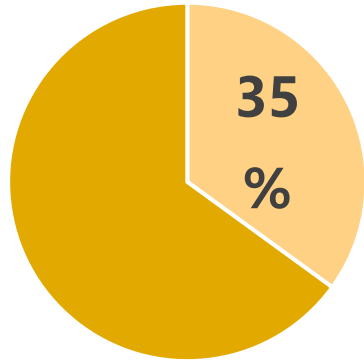


**Lack of
kindergartens**



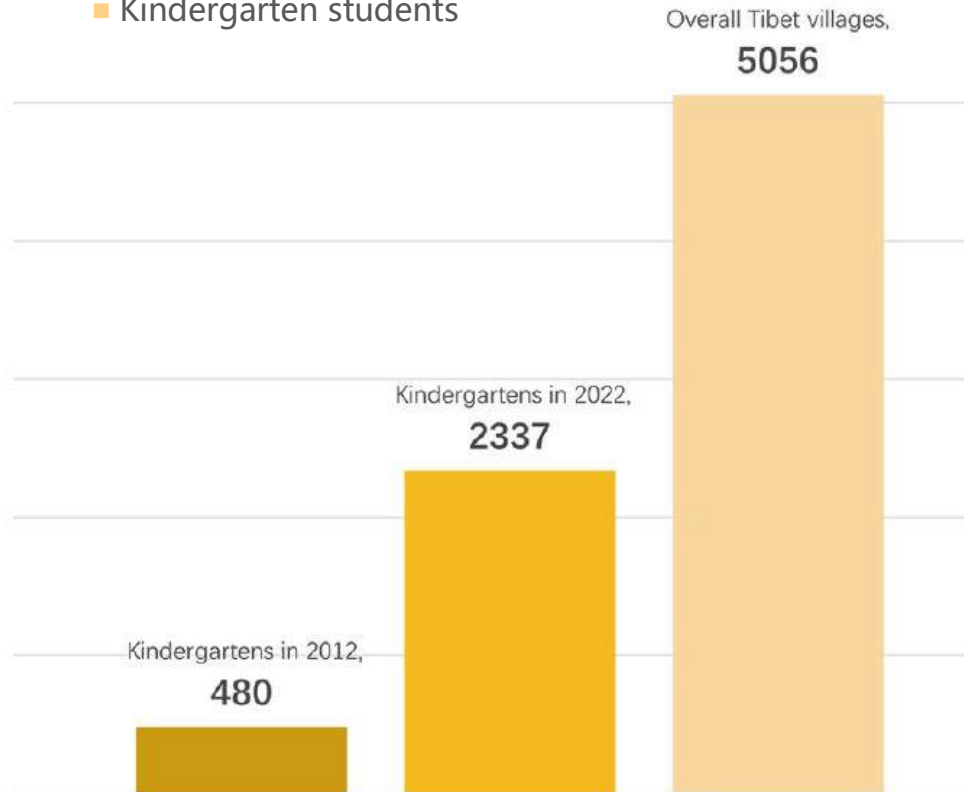
**Demand of
revitalization**

Lack of kindergartens



Low kindergarten attendance rate in 2011

Kindergarten students



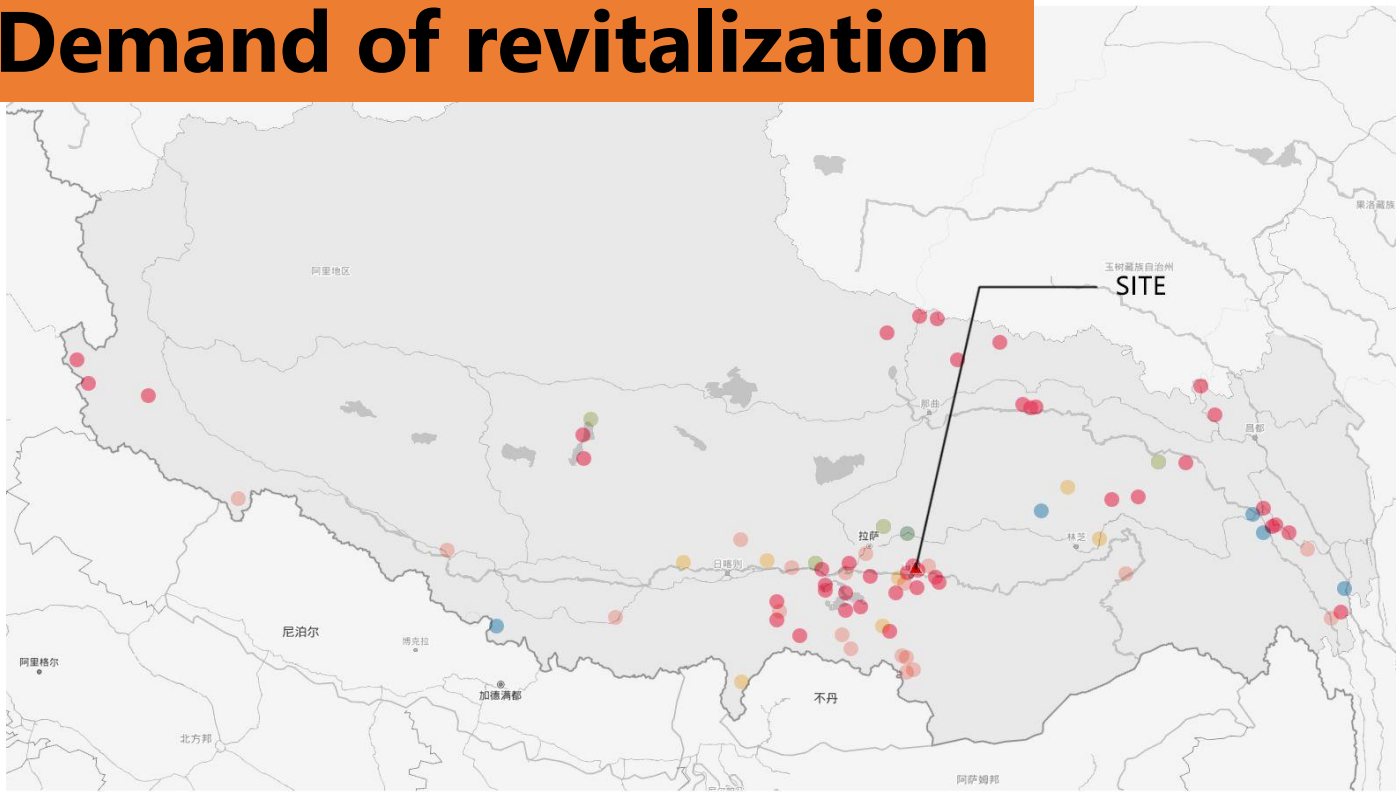
2011
Kindergarten education included in
15 YEARS of free education

2012
480 kindergartens across Tibet

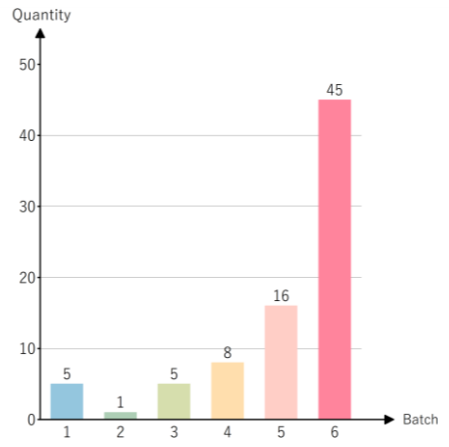
2023
2199 kindergartens across Tibet
Overall 5256 villages in Tibet

OVER 50% of villages in Tibet
don't have their own kindergartens

Demand of revitalization



- The sixth batch of villages listed in the list of Chinese traditional villages
- The fifth batch of villages listed in the list of Chinese traditional villages
- The fourth batch of villages listed in the list of Chinese traditional villages
- The third batch of villages listed in the list of Chinese traditional villages
- The second batch of villages listed in the list of Chinese traditional villages
- The first batch of villages listed in the list of Chinese traditional villages



Increasing Tibetan villages in government's **revitalization plan**, calling for retrofit of misused public buildings.



CHALLENGES

Challenges

01 How can we construct kindergartens **efficiently and economically**?

02 How to preserve the **nature** of children?

03 How can we take advantage of **the existing building**?

04 How to address **resource scarcity** and **pollution**?

CONCEPT

Challenges

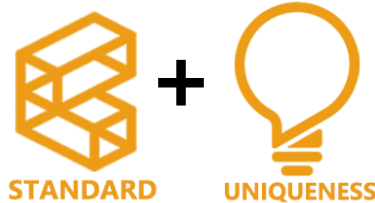
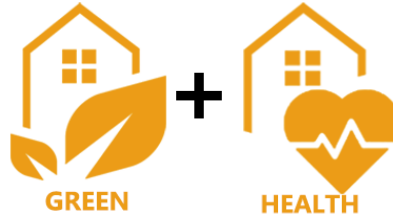
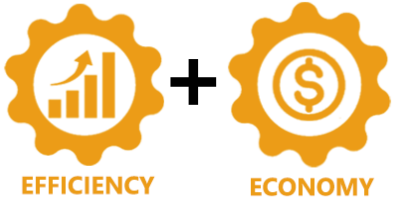
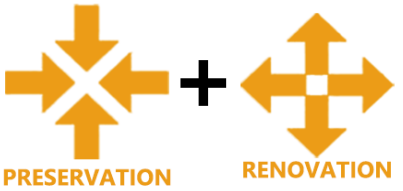
How can we construct kindergartens **efficiently** and **economically**?

How to preserve the **nature** of children?

How can we take advantage of **the existing building**?

How to address **resource scarcity** and **pollution**?

Concepts



Contests

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community



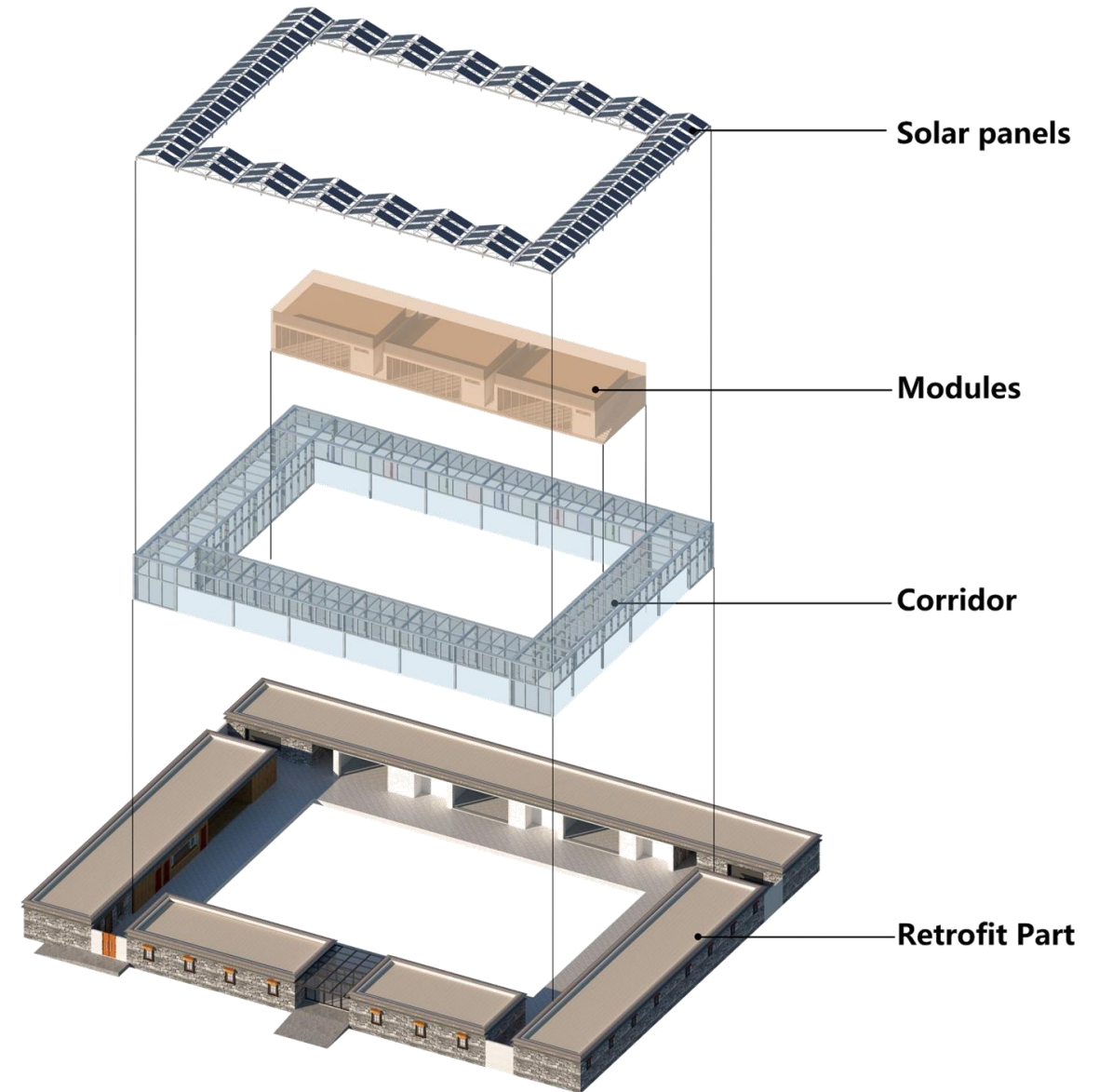
STRATEGIES



Innovation

Preservation & Renovation

- Maintain the layout of the existing building and its surroundings
- Preserve existing building facades and materials
- Expand the space inward without destroying the original building
- Fusion of new technology image and Tibetan style



Form and function



Solar Corridor

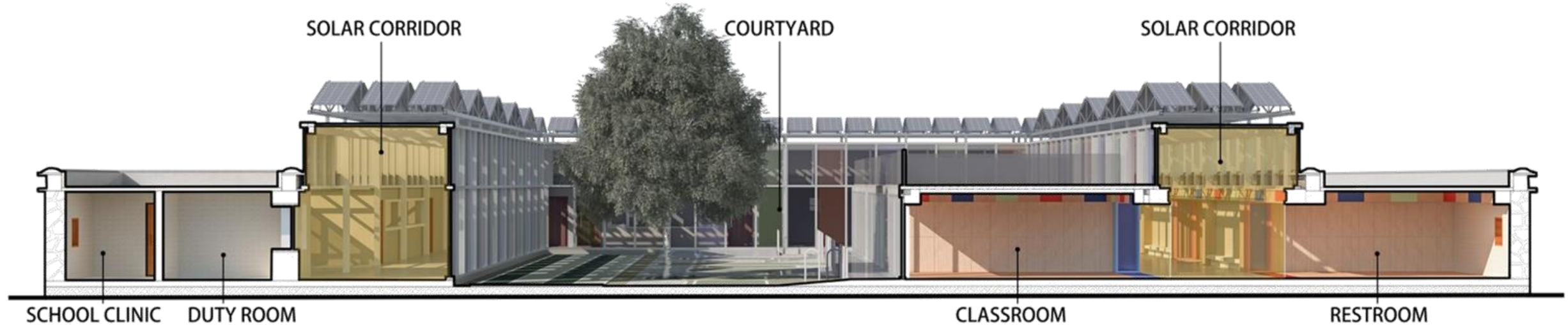
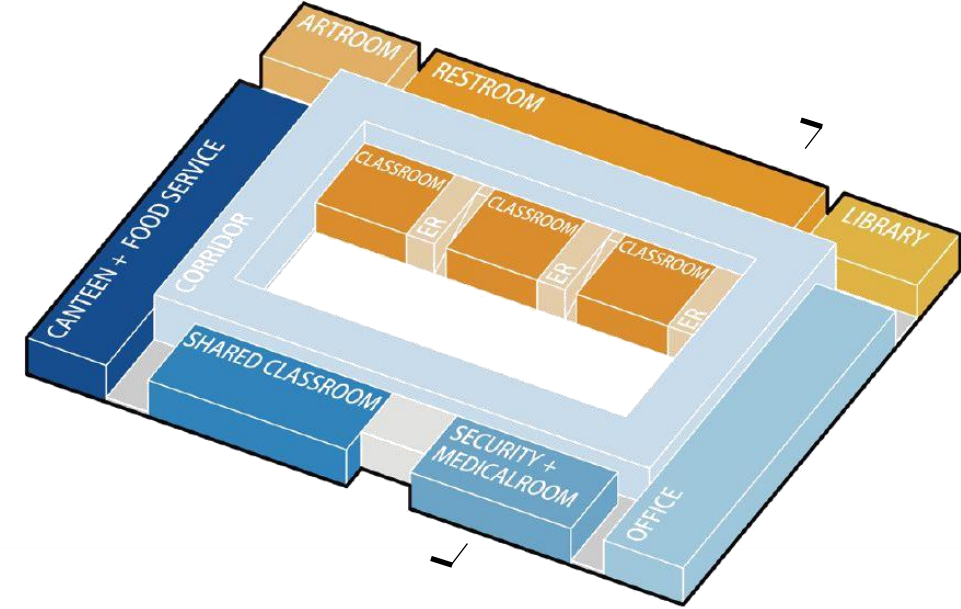
Safe and comfortable communal space for children

Unit classroom and restroom

Safe teaching area for children

Open courtyard

Outdoor activity areas for each class



View of Entrance



View of Courtyard



View of Solar Corridor



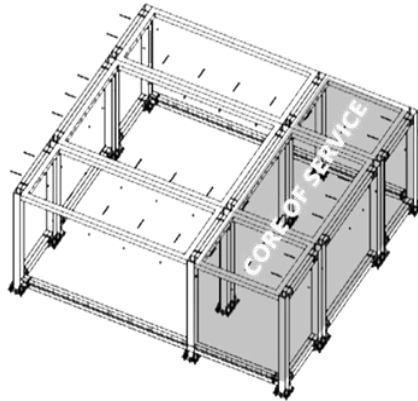
View of Classroom Module



Product Mode

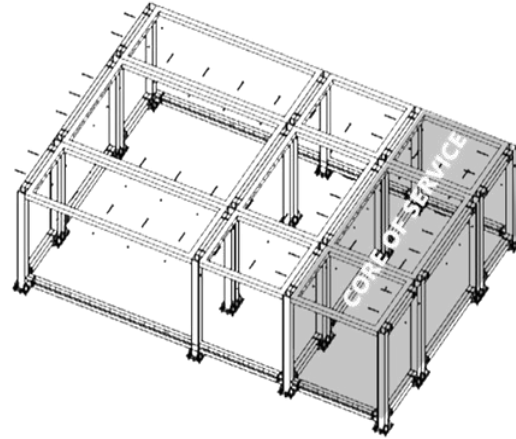


A



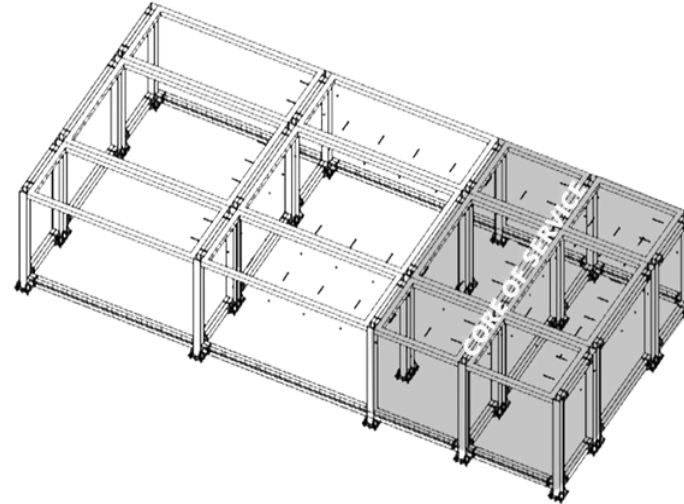
Classroom for 5 students

B

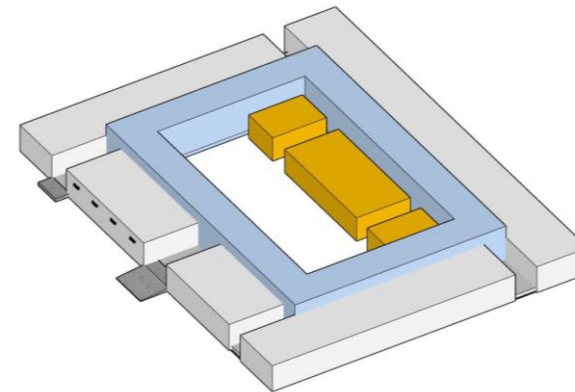
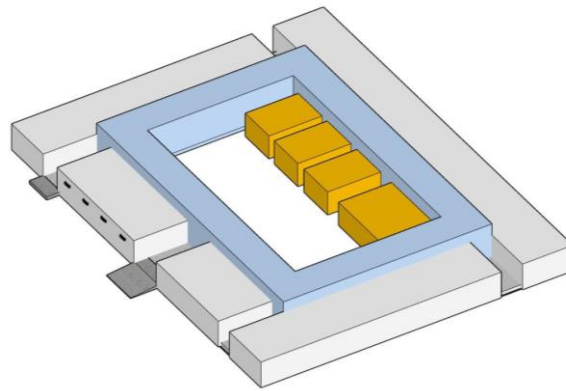
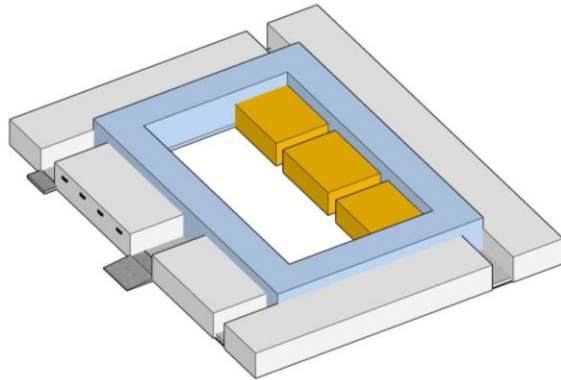


Classroom for 10 students

C



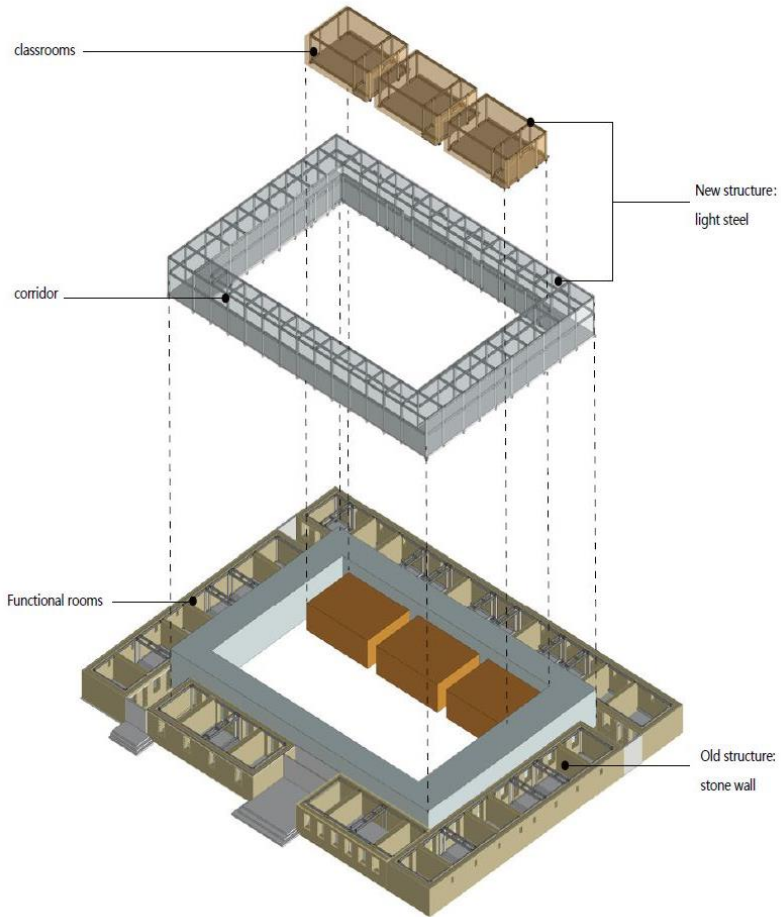
Classroom for 15 students



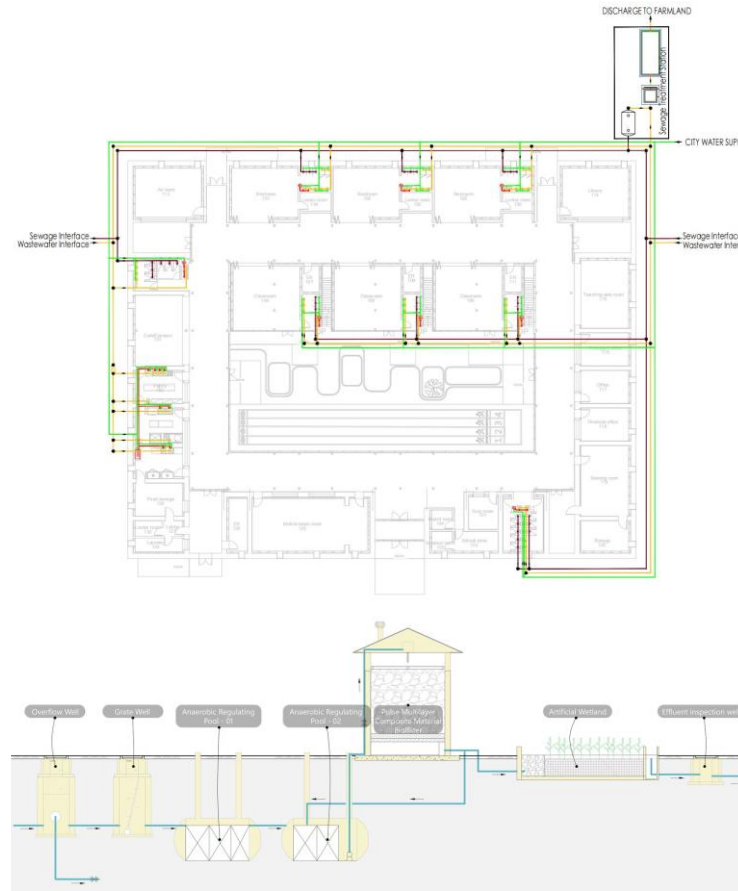
Engineering system



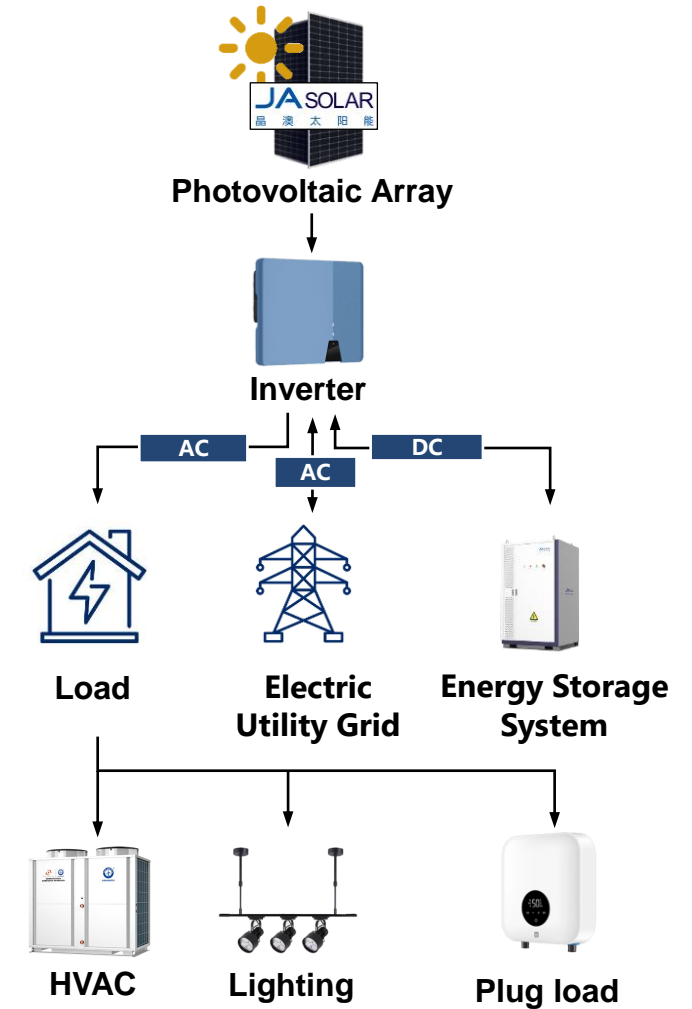
Structure system



Plumbing & Sewage treatment system



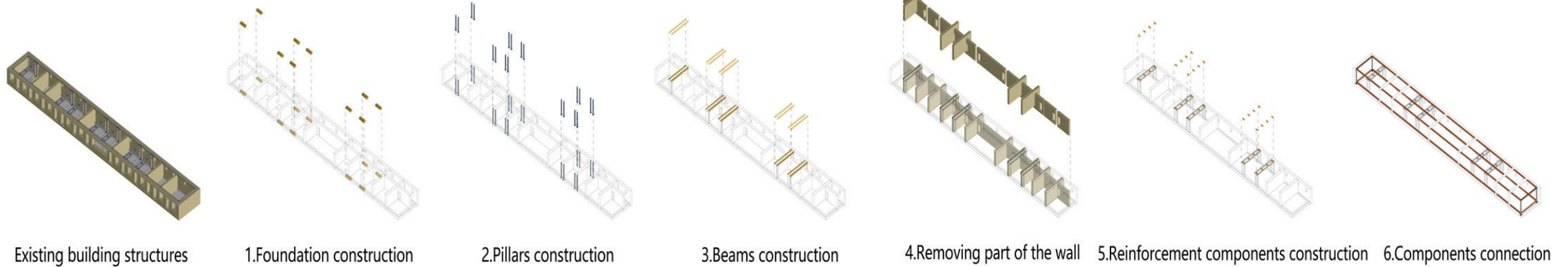
Renewable energy & Mechanical systems



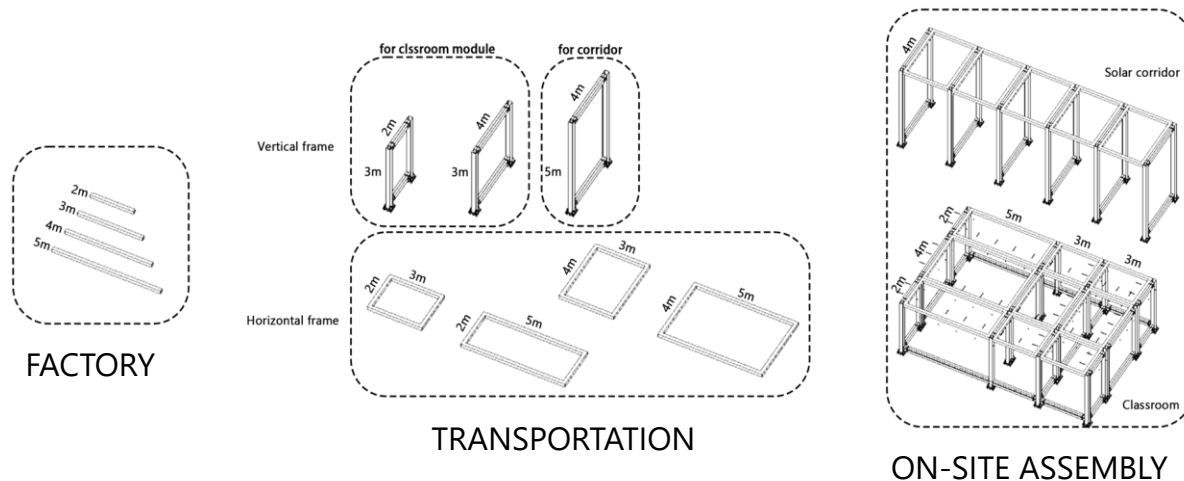
Structure system



Structure Retrofit



Structure expansion



- Frames for on-site assembly
- Modulus with higher flexibility
- All-bolt connections

Innovation

Standardized prefabrication

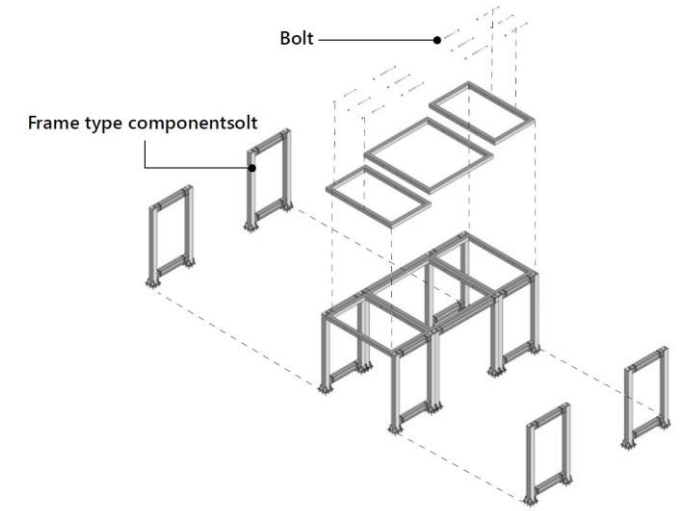
Safety of components during transportation

Higher efficiency of on-site assembly

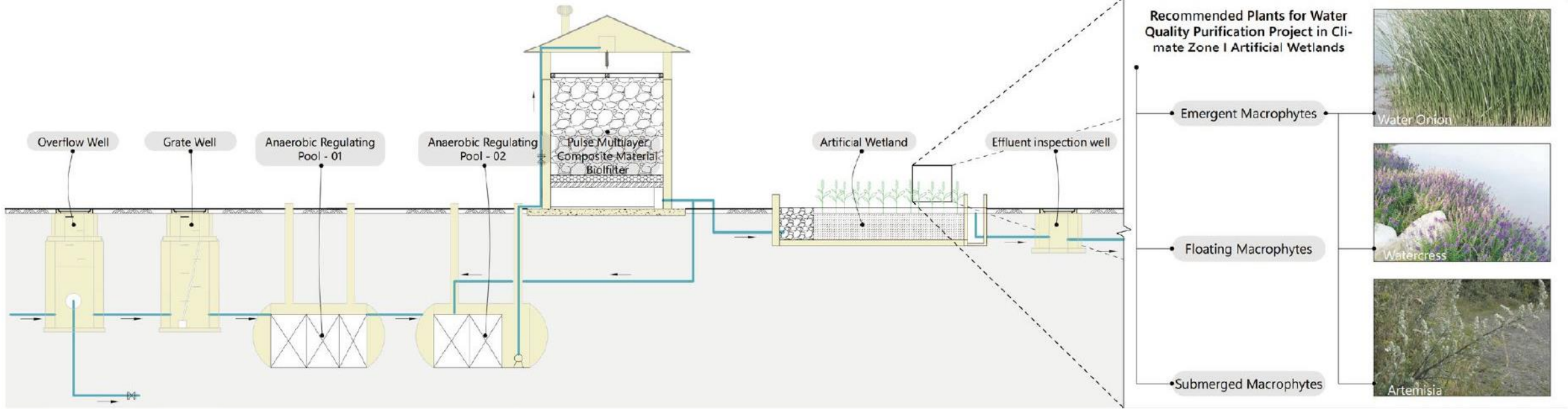
Support upgrading in the future



- Frames for on-site assembly
- Modulus with higher flexibility
- All-bolt connections



Sewage treatment



Load calculation

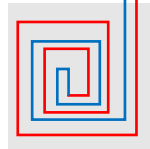


Air sourced heat pump



220 V/1-180 VA

Underfloor heating loop



KD-66N1/BP

Radiator



Bidirectional full heat purification fresh air system



250m³/h
150w

Mini electric Water Heater for instant hot water



Q=86kw
P=5500w

LED Spotlight



P=16w

LED Lawn lamp



P=10w

LED Ceiling light
P=10w



LED Spotlight
P=16w



Monthly energy consumption composition				
	Lighting [kBTU]	Plug loads [kBTU]	HVAC[kBTU]	No.
January	27298.24	18955.98	78898.48	1
February	19498.73	13539.99	55551.05	2
March	28598.12	19858.65	71990.47	3
April	22098.54	15345.30	0.00	4
May	25998.31	18053.31	0.00	5
June	24698.38	17150.64	0.00	6
July	29898.00	20761.30	0.00	7
August	27298.24	18955.98	0.00	8
September	24698.38	17150.64	0.00	9
October	22098.54	15345.30	0.00	10
November	27298.24	18955.98	66498.84	11
December	27298.24	18955.98	72837.46	12



Existing condition of envelope



Broken Structure

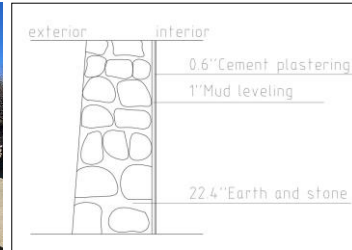
Lack of Insulated

Lack of Air Sealing

Poor Waterproofing

No Interior Finishing

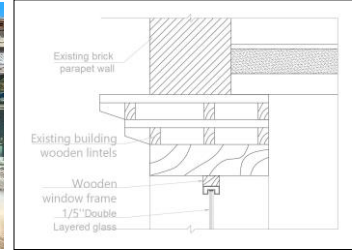
Existing building wall



R-2.2

ft²·hr·°F/BTU

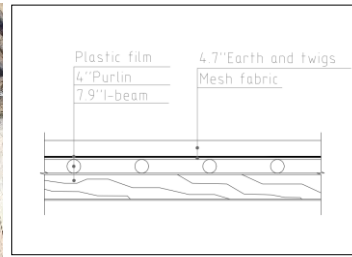
Existing building windows



U-2.7

W/m²·K

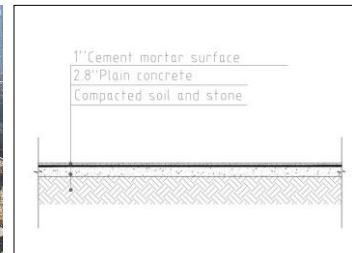
Existing building roof



R-2.3

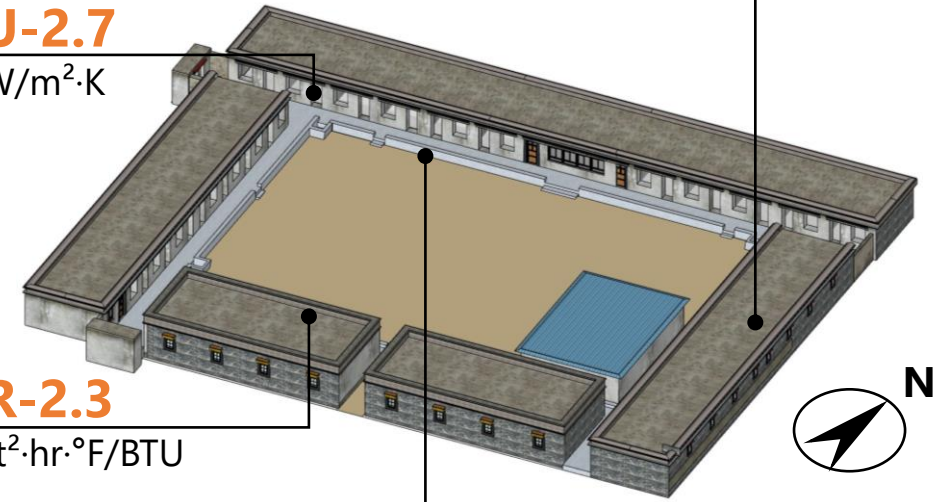
ft²·hr·°F/BTU

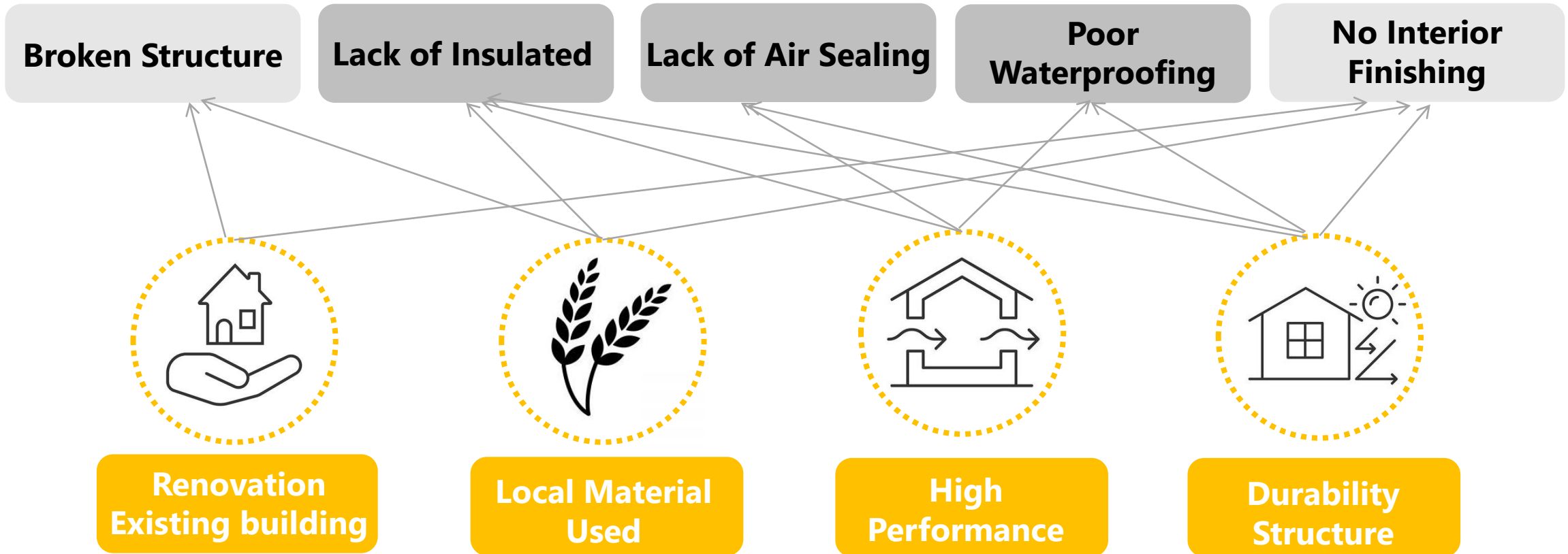
Existing building floor



R-1.9

ft²·hr·°F/BTU





Response to climate risk



Climate Zone: Cool (5C)

Low Temperature



Average maximum temperature: 84.2°F
Average minimum temperature: -13°F

Low Rainfall



July is the most rainfall with an average rainfall of 78mm, January is the driest month with an average rainfall of 0mm.

Climate Risk

Drought



The longest drought lasts for 7.5 months

Frost



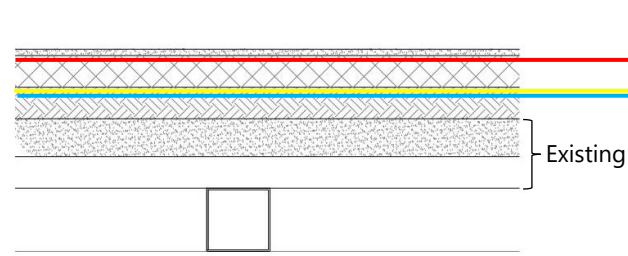
60% of the total disaster in April

Snow

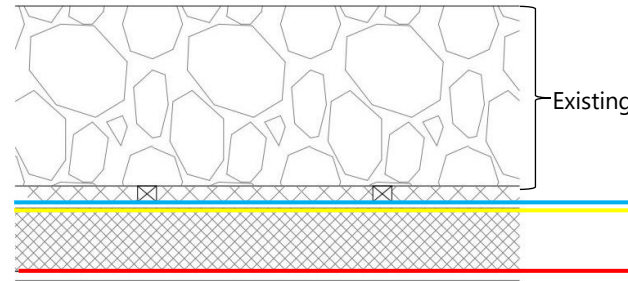


Snowfall is concentrated from December to February

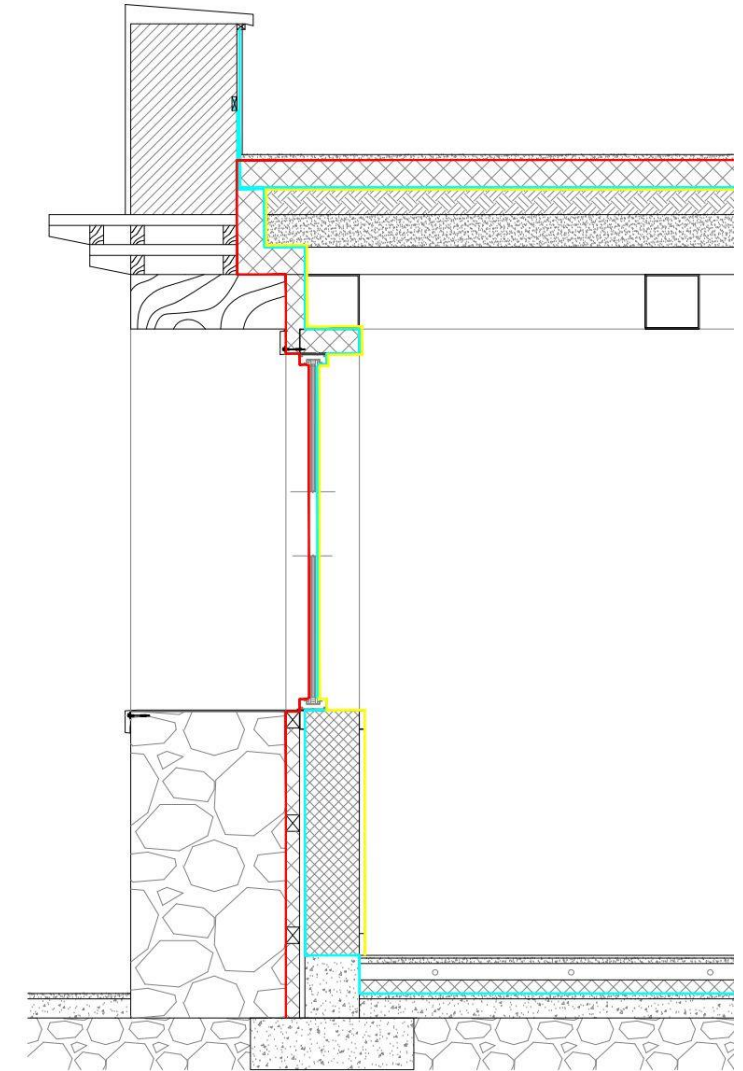
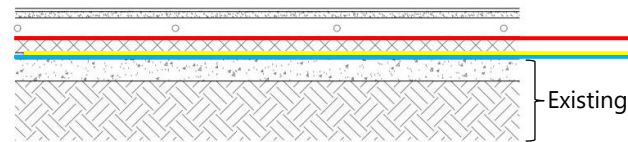
Roof Section View R-31



Wall Section View R-21



Floor Section View R-25

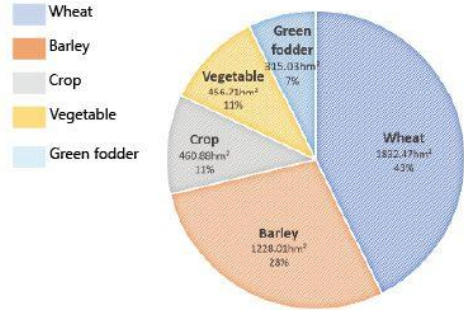


● Air Barrier ● Thermal Barrier ● Moisture Barrier

Materials

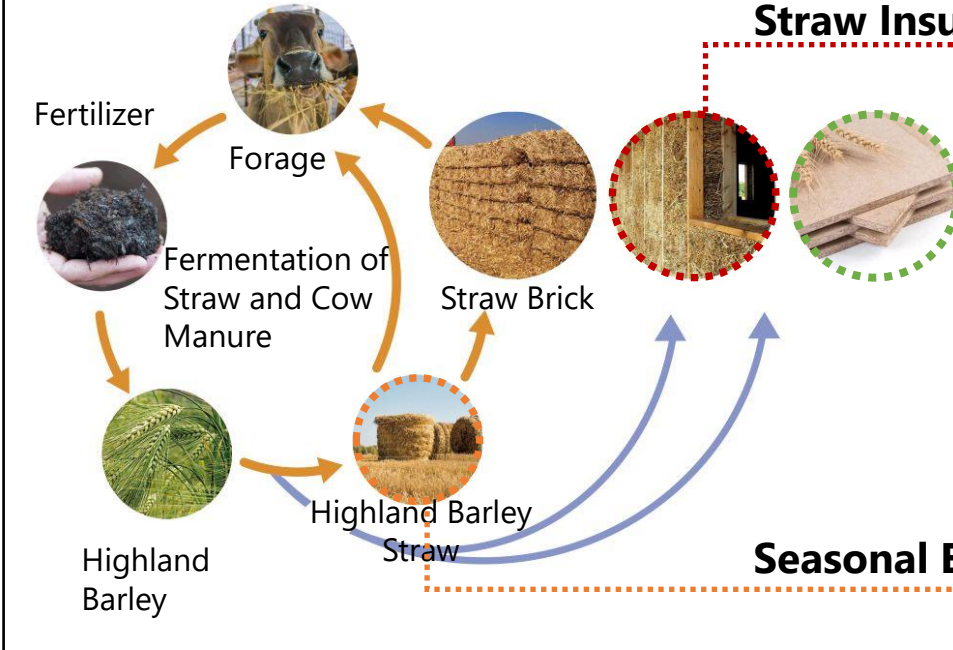


Strategies of Local Straw Cycle

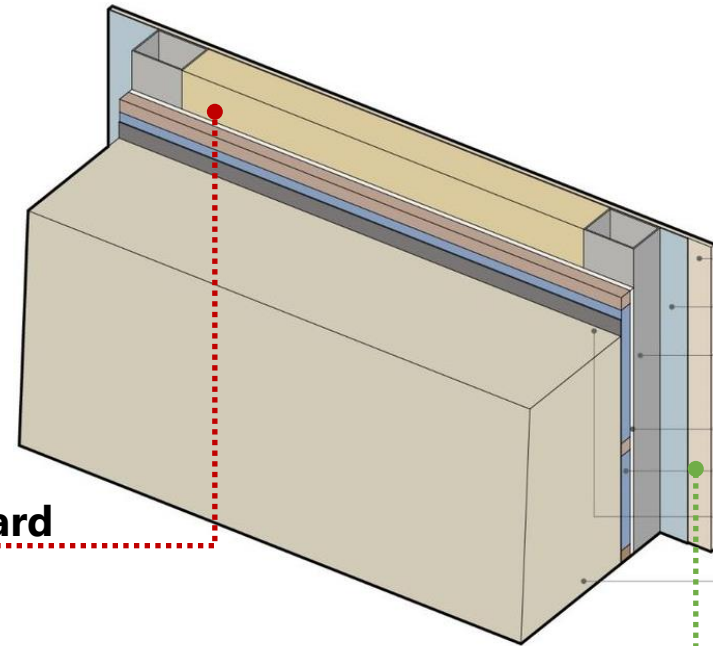


The wheat yield is **12167** tons and the barley yield is **12100** tons in 2022.

Straw Insulation Board

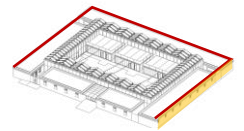


Straw Decorative Panel

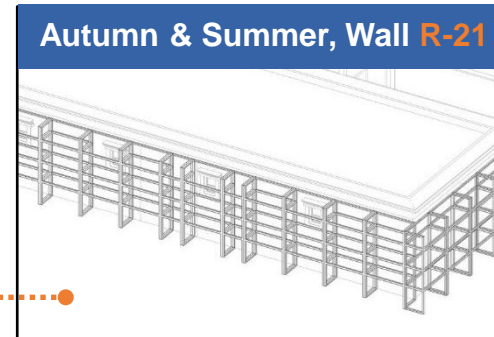


R-21

- 4/5" EBF inorganic straw board
- Polyurethane vapor barrier membrane
- 8x8 Lightweight square steel column, embedded with straw
- 4/5" Cement fiberboard
- 2" Furring channel & Insulation layer
- Waterproof breathable membrane
- Existing earth and granite wall



Seasonal Edible Envelope



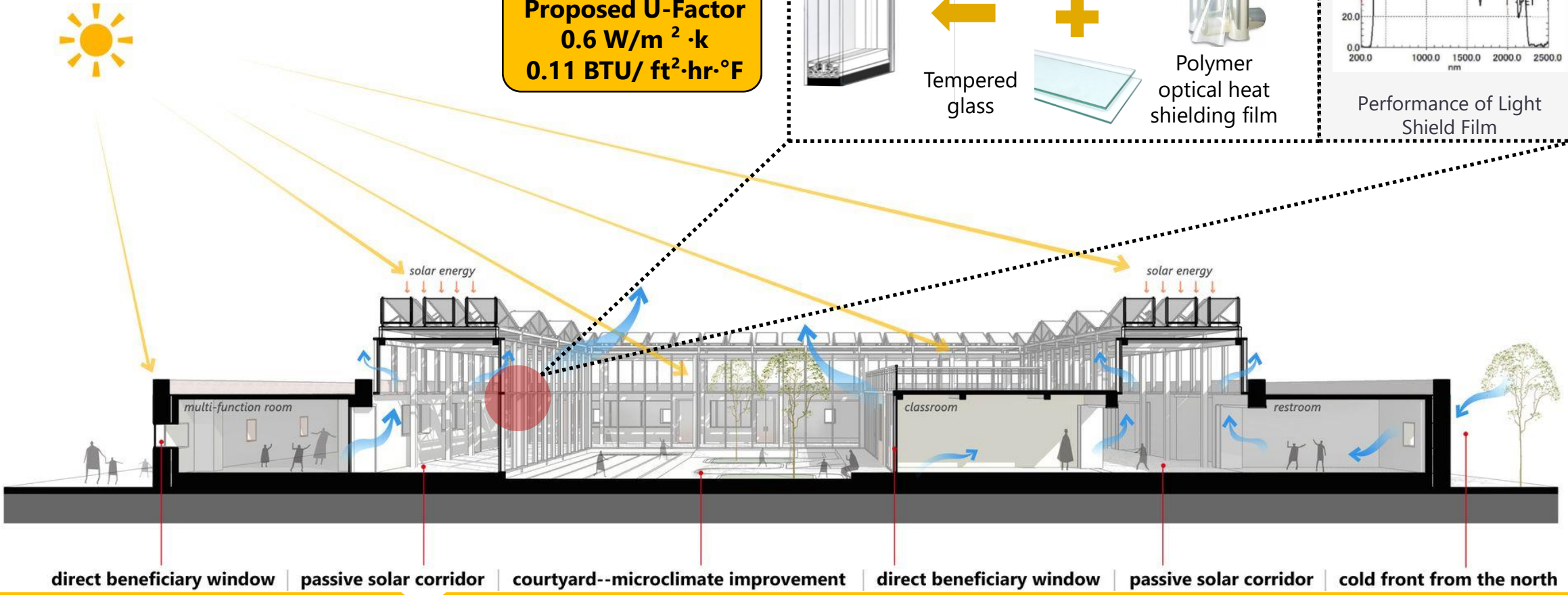
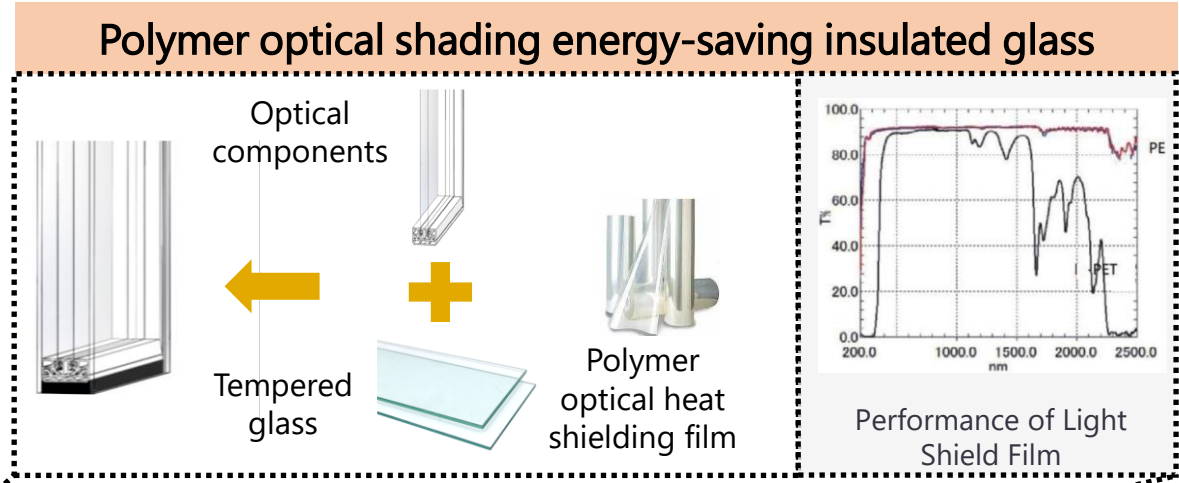
Passive Design



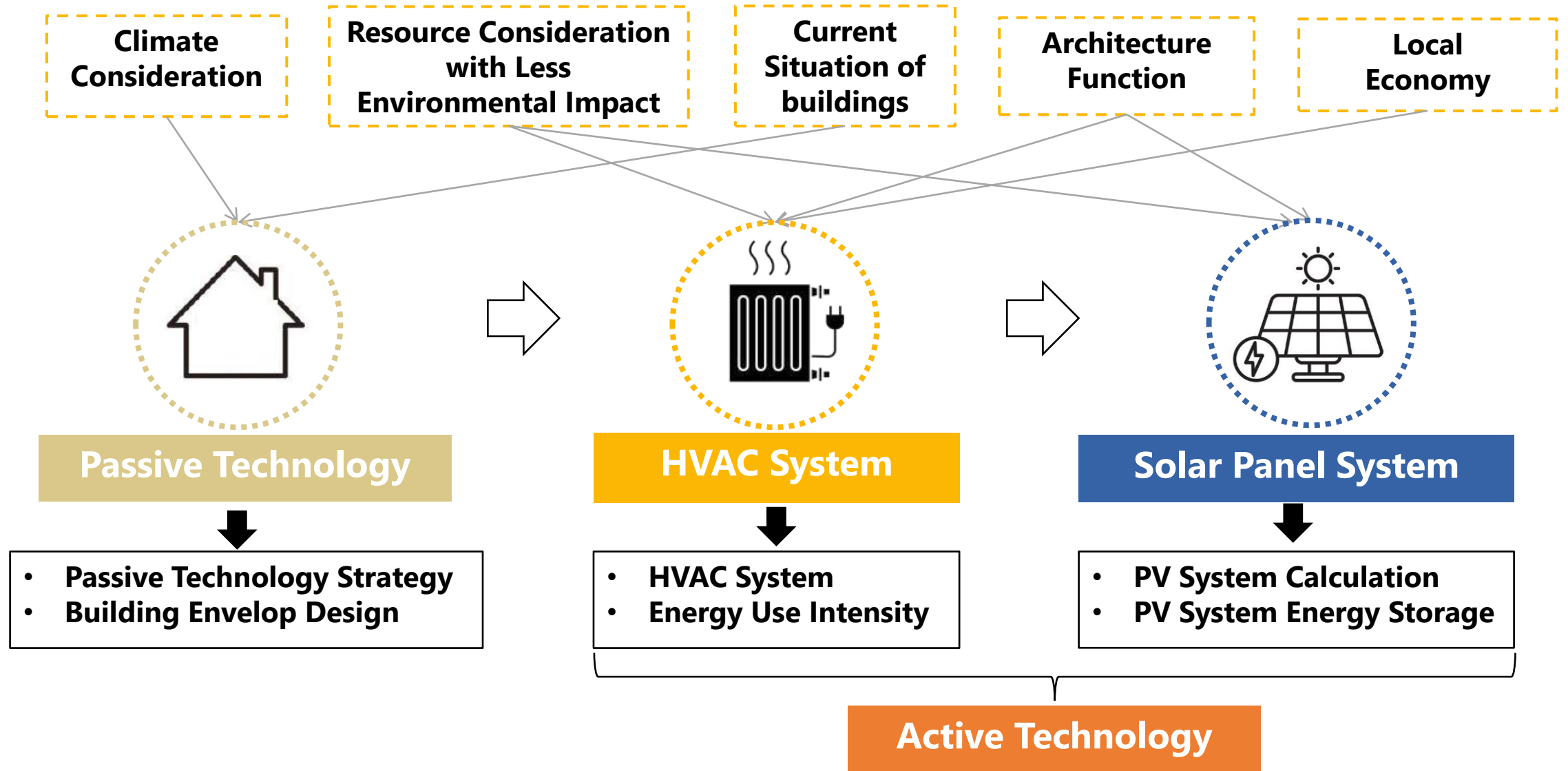
Multi-cavity windows & Climate Sun Corridor

Existing U-Factor
 $2.7 \text{ W/m}^2 \cdot \text{k}$
 $0.48 \text{ BTU/ft}^2 \cdot \text{hr} \cdot \text{°F}$

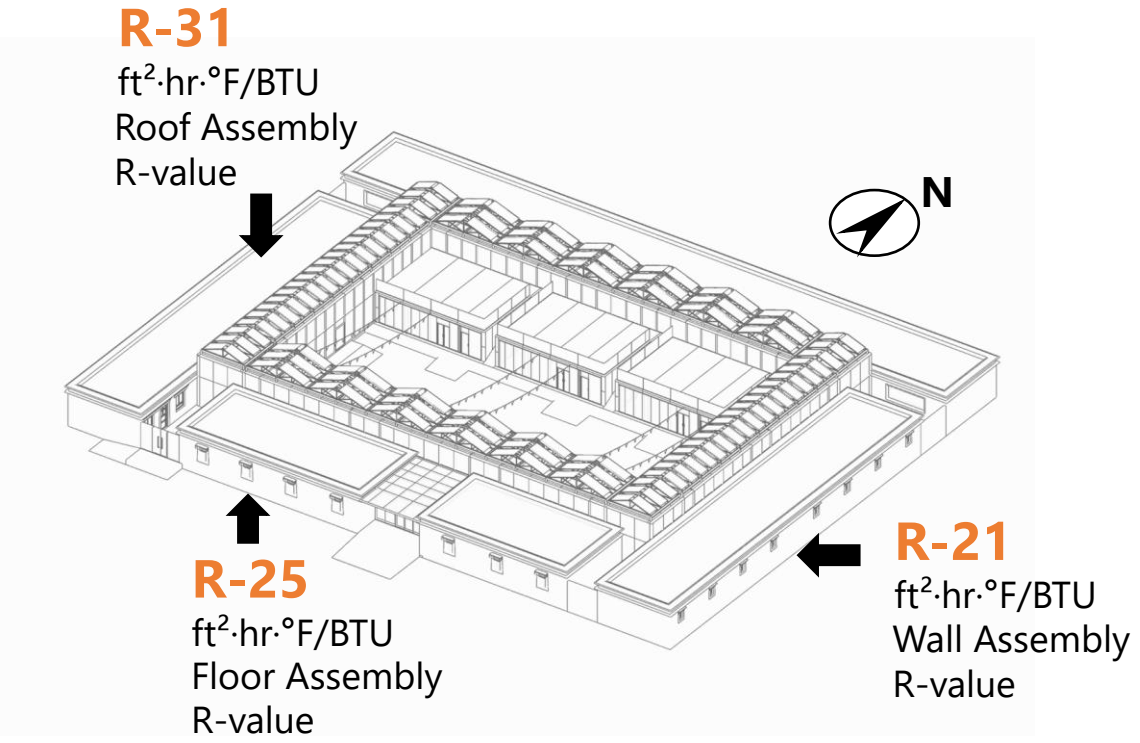
Proposed U-Factor
 $0.6 \text{ W/m}^2 \cdot \text{k}$
 $0.11 \text{ BTU/ft}^2 \cdot \text{hr} \cdot \text{°F}$



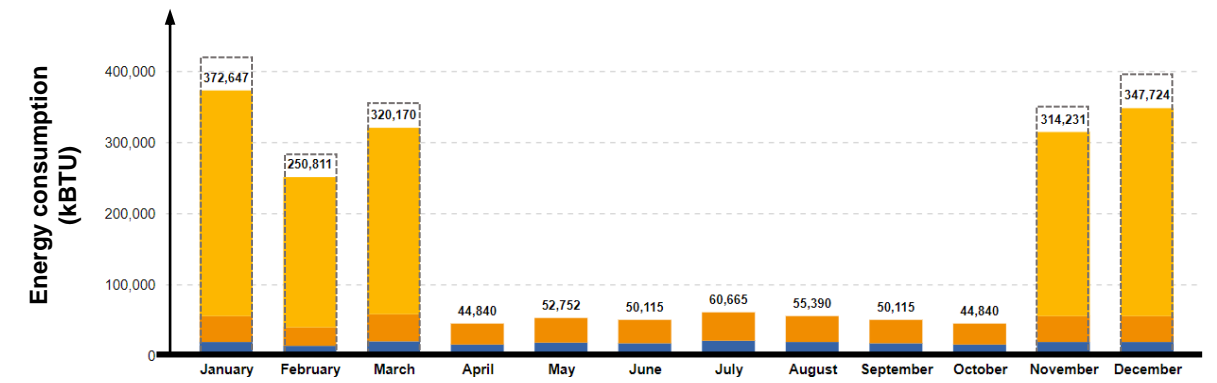
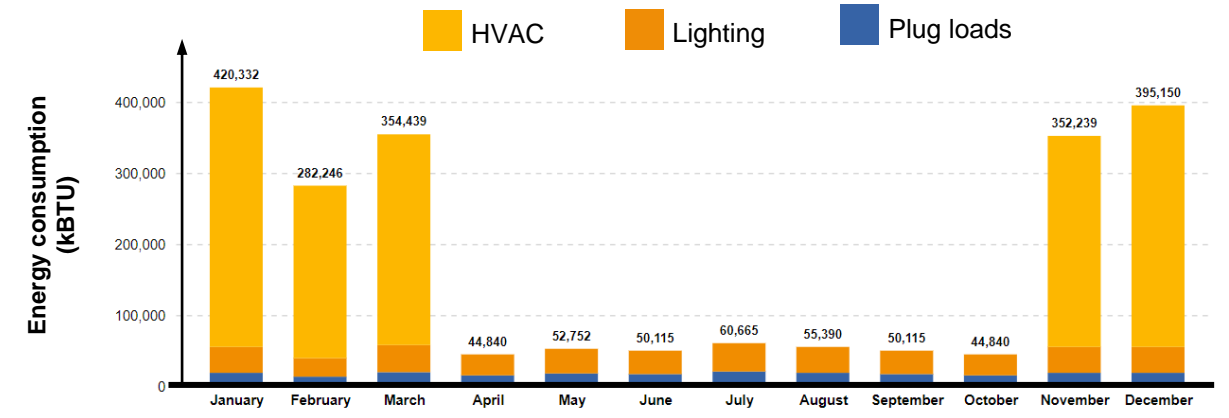
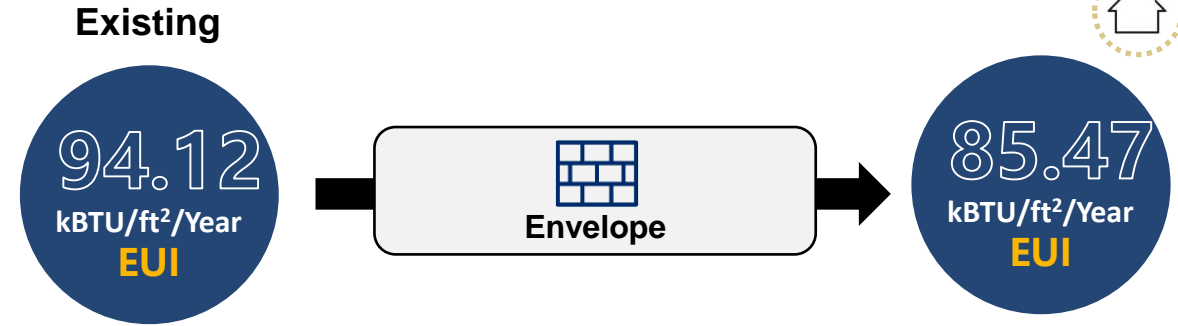
Strategy



Operation savings



	Existing R-Value	Proposed R-Value	Existing U-factor	Proposed U-factor
Roof	2.3	31	-	-
Wall	2.2	21	-	-
Floor	1.9	25	-	-
Window	-	-	0.48	0.11



Maintenance and operability



Air heat pump

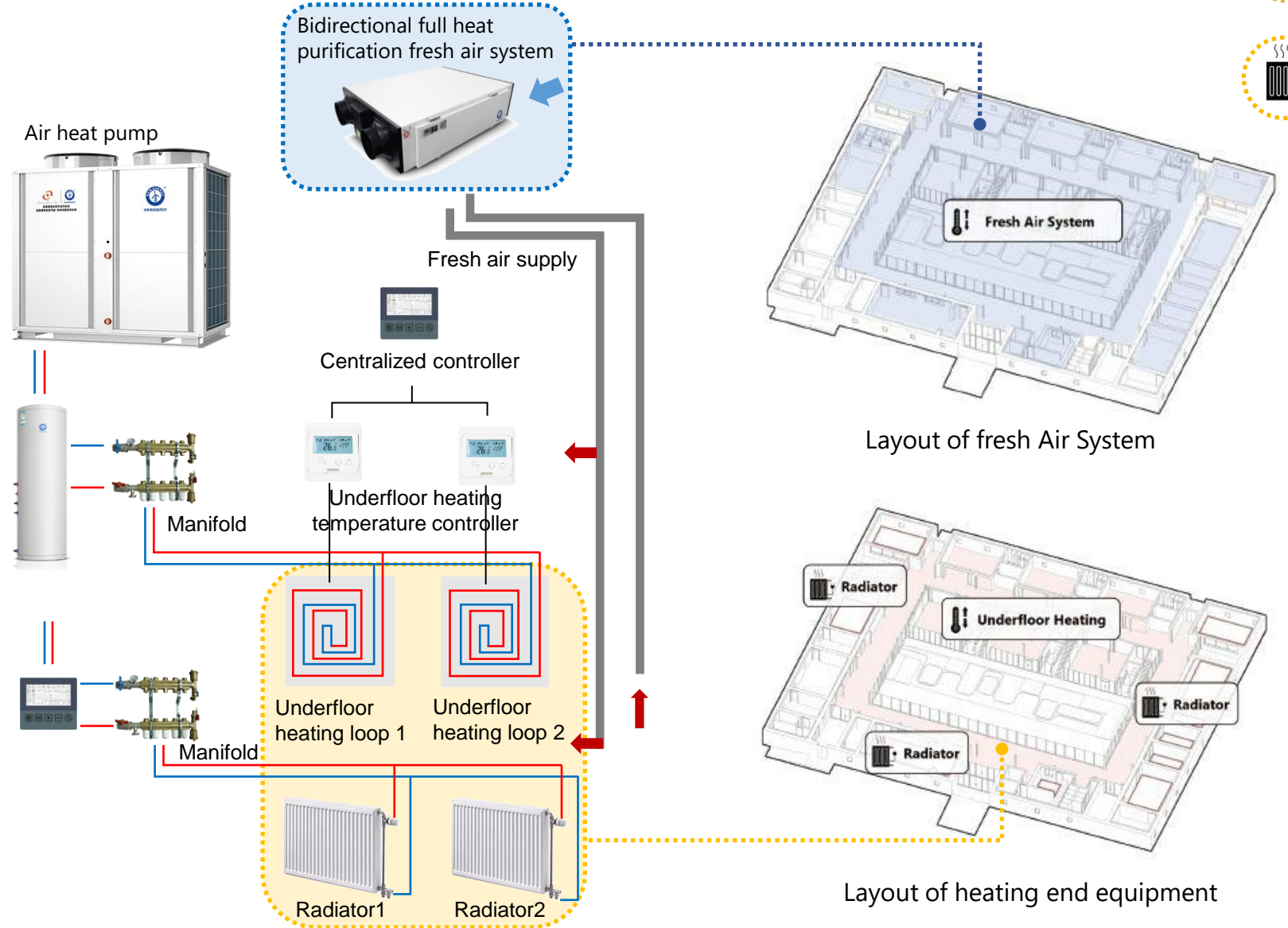


- The high-efficiency coupled heating system of gas boiler and air source heat pump
- Zonal regulation

Ventilation system



- Heat recovery
- Zonal regulation



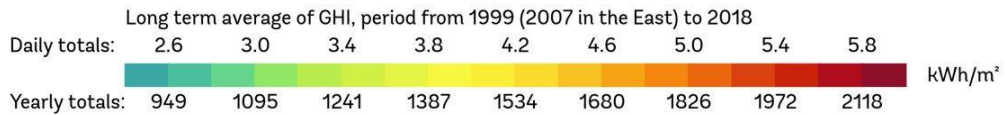
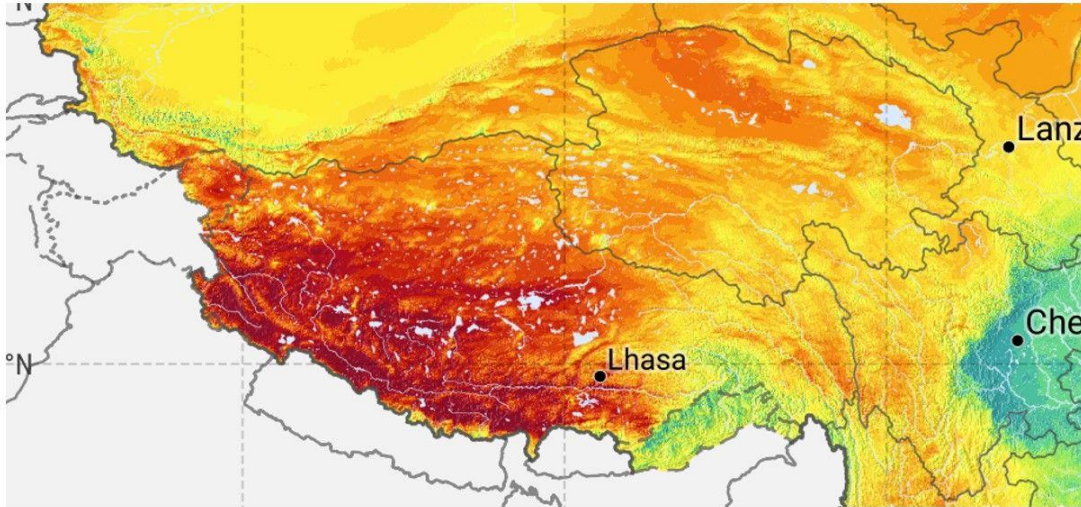
Operational carbon emission

Solar energy utilization potential

SOLAR RESOURCE MAP

GLOBAL HORIZONTAL IRRADIATION

CHINA Tibet

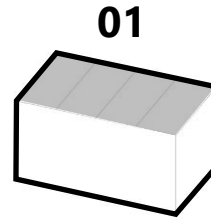


This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit <http://globalsolaratlas.info>.

<https://globalsolaratlas.info/>

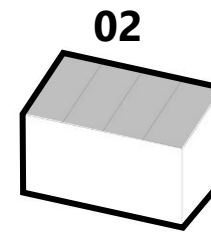
Photovoltaic Power Potential in Tibet

Kindergarten in Sangga-Education Division



01
Flat-Southward

AC Energy:
1125777.12kBTU



02
Tilt 20°-Southward

AC Energy:
1271908.98kBTU



03
Tilt 20°-
Eastward&Westward

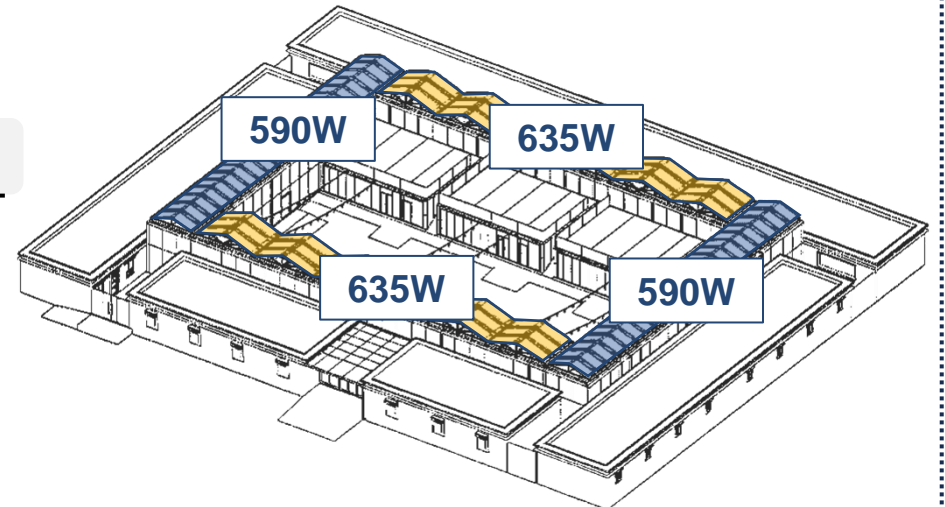
AC Energy:
1457115.07kBTU

East-west solar photovoltaic panel layout

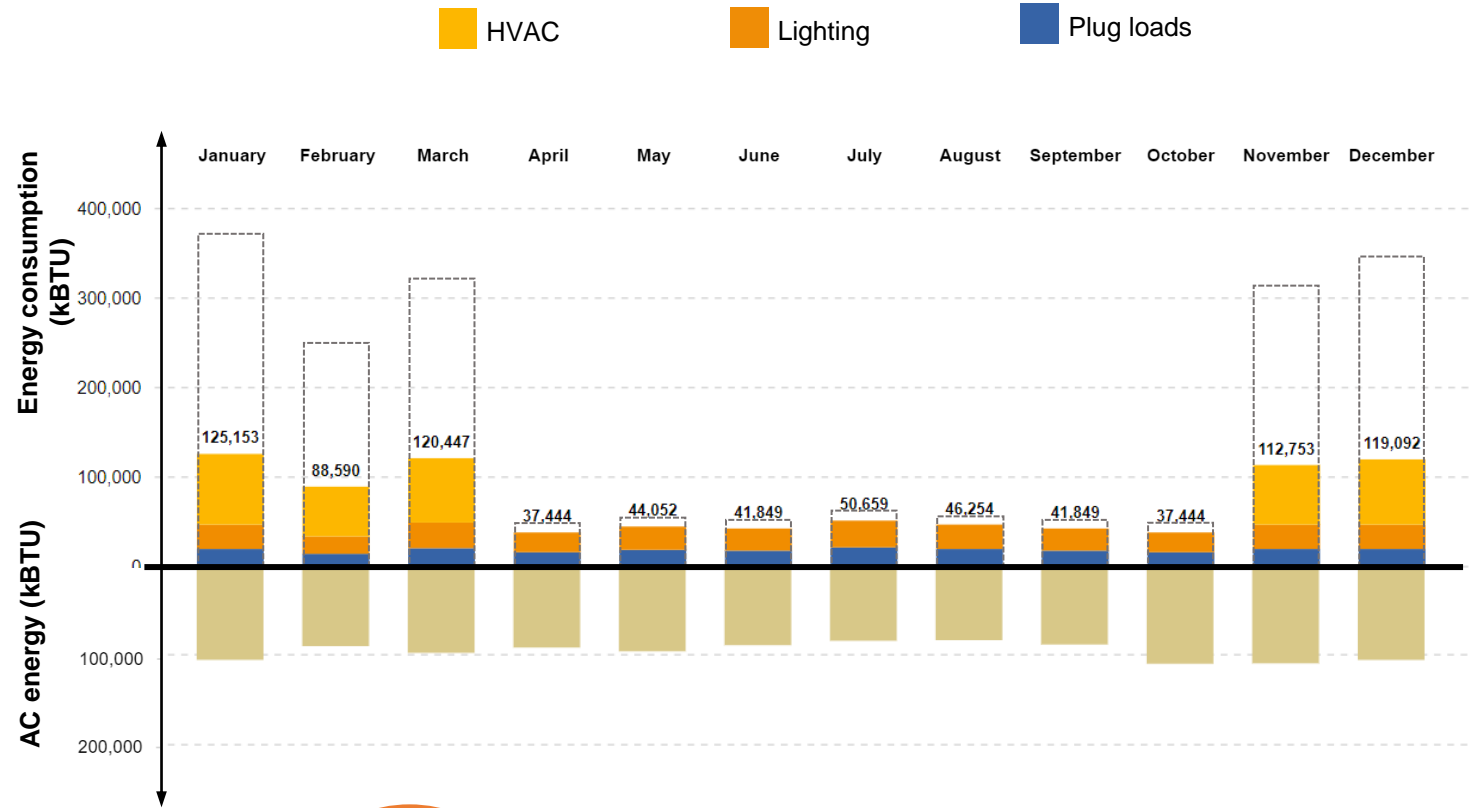
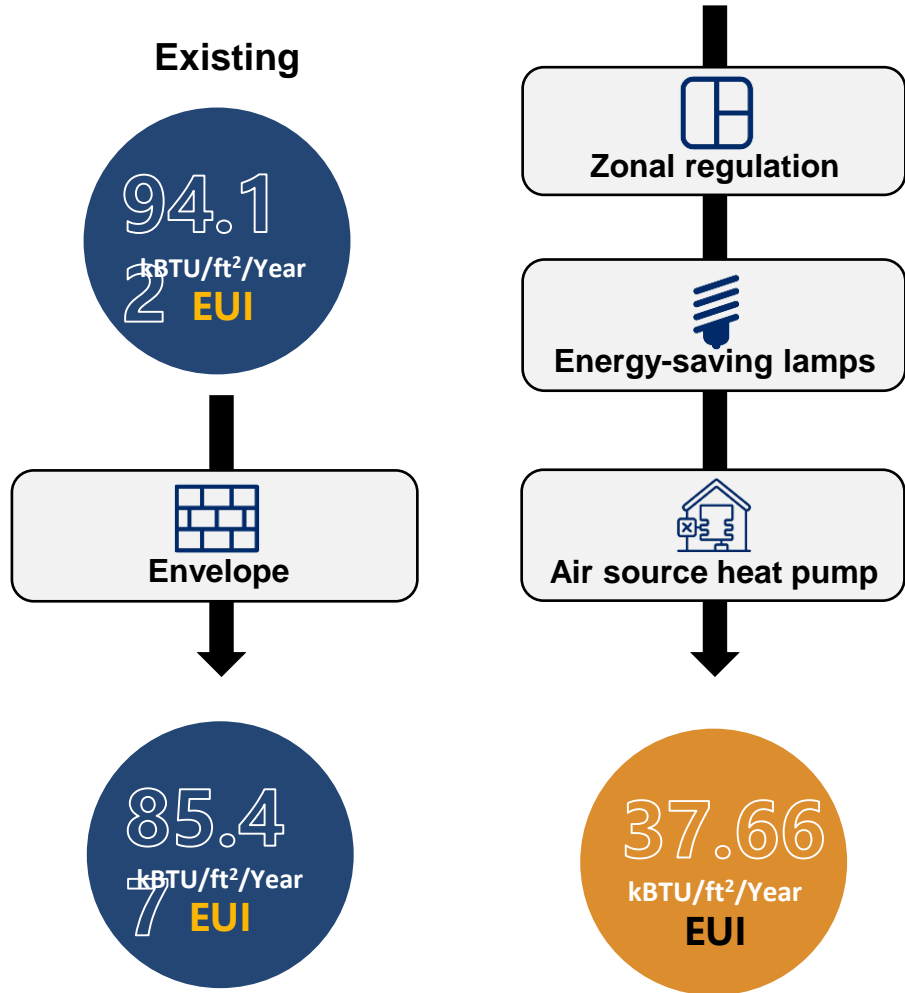
Roof mounted PV

160 PANELS

**1457115.07
kBTU per year**



Operational carbon emission



$$\begin{matrix}
 \text{PV} \\
 63.4 \\
 \text{kBTU/ft}^2/\text{Year} \\
 \text{EUI}
 \end{matrix}
 =
 \begin{matrix}
 0 \\
 \text{kBTU/ft}^2/\text{Year} \\
 \text{EUI}
 \end{matrix}
 =
 25.74
 \text{ kBTU/ft}^2/\text{Year}$$

Resilience

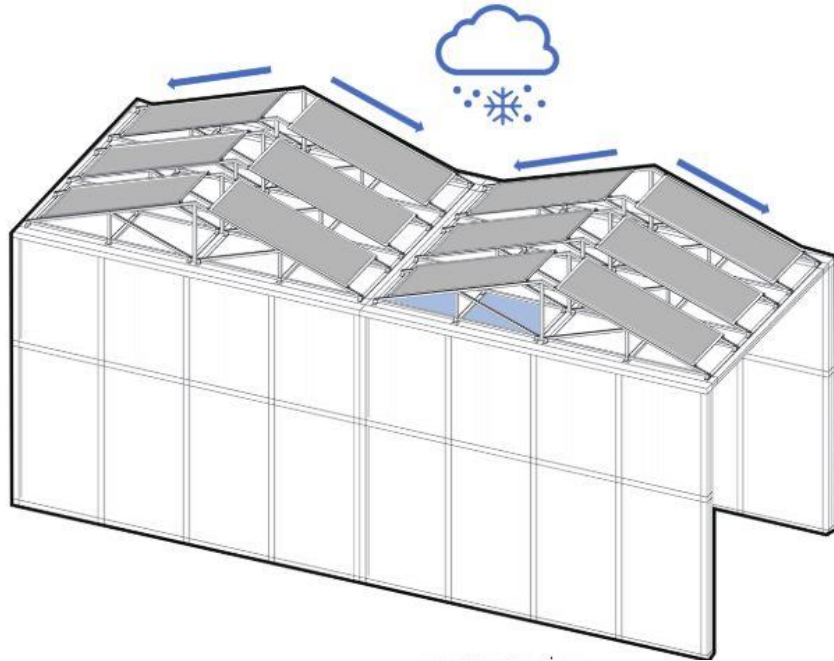


Snow Disaster

Solar panels have **independent** east-west mounts to prevent snow buildup.

Energy storage batteries provide prompt response.

Light steel frame structure reinforced to support loads.



Grid Outage

01

Generation power > Load power



02

Generation power = Load power



03

Generation power < Load power



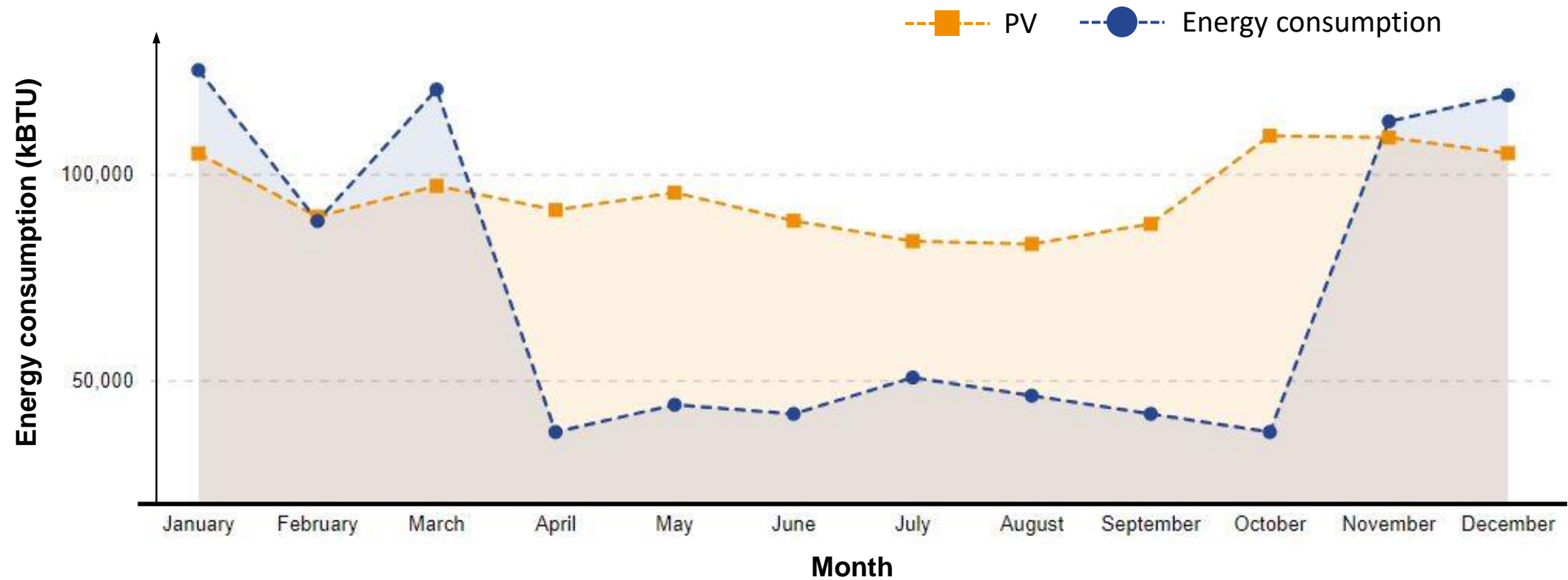
04

Power generation is normal, and there are no load consumption



Energy supply and demand

Kindergarten in Sangga-Education Division

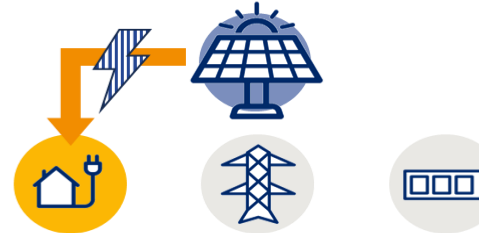


Innovative energy management solutions



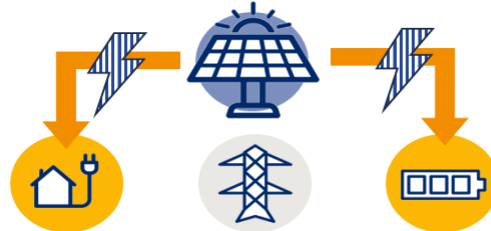
01 Generation power = Load power

No charge or discharge the battery

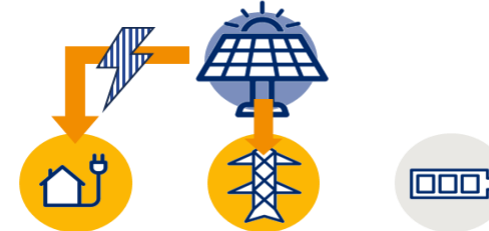


02 Generation power > Load power

Excess power is stored in the battery

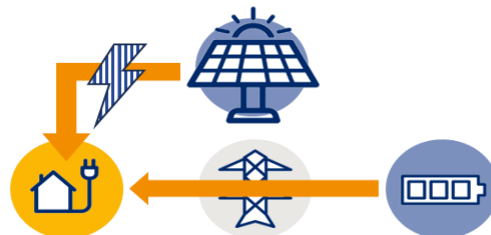


If the battery is full, the remaining power is sent to the grid



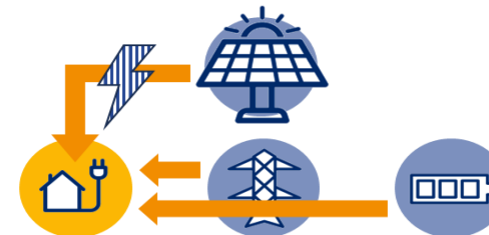
03 Generation power < Load power

Battery discharge to power loads



04 PV power + Battery power < Load power

Purchasing power from the grid to feed the load



Load



Electric Utility Grid



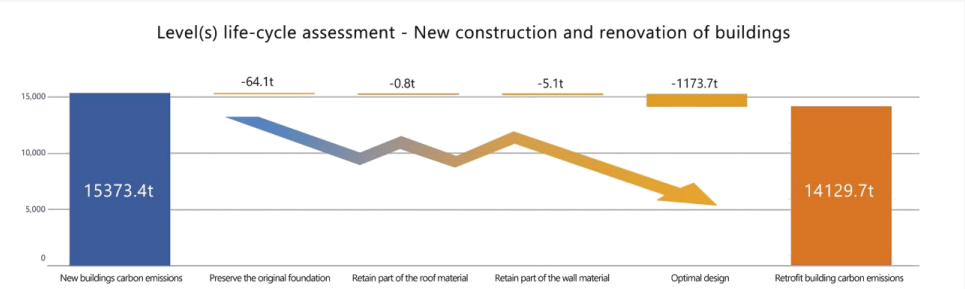
Energy Storage System

Material selections and design decisions

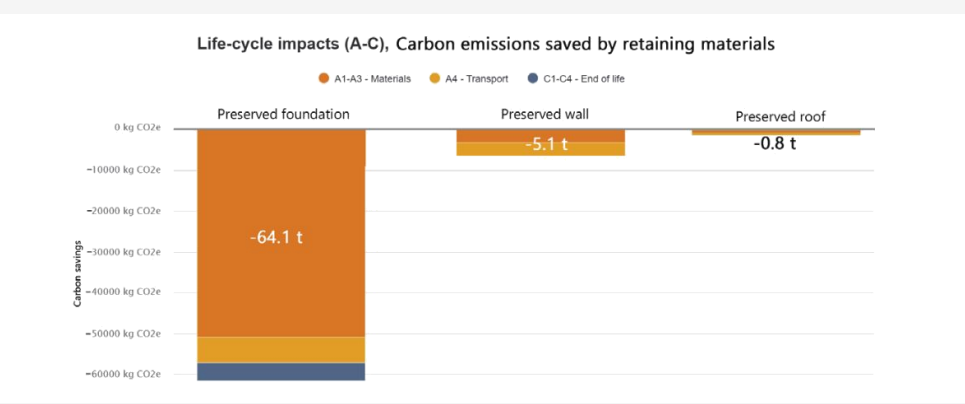


Retrofitting

Reduce carbon emissions from **new material production and transportation**

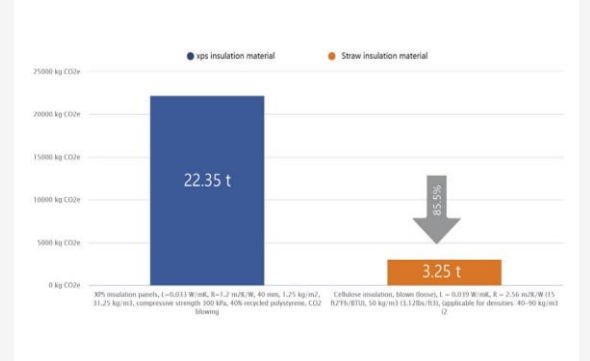


Reduce **the waste generated by the demolition of the building structure**



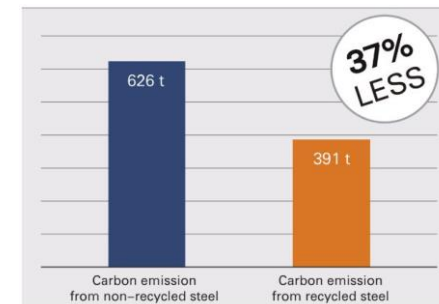
Local straw are used as insulation layer

Improve **the thermal performance** of the building and avoid the **long-distance transportation** of materials



Prefabricated light steel system

Reduce the embodied carbon emissions of **on-site construction**
Reduce **the need for new materials** due to their dismantling and recycling at the end of the building's useful life



Inorganic straw boards are used for the interior finishes

Reduces the large amount of carbon emissions generated by **the cement mortar construction layer**

Life cycle assessment



• Embodied carbon emission •

391 kgCO₂e/m² < 450 kgCO₂e/m² →

Carbon Heroes benchmark

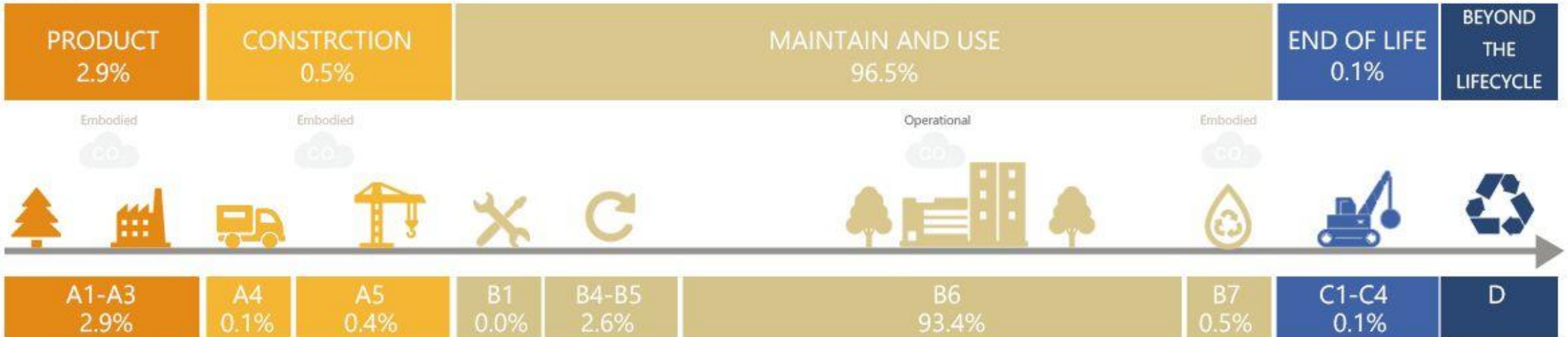
level A

By Cradle to Grave

• Life-cycle carbon emission •

112.53 kgCO₂e/m²/Year

STAGE



MODULE

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

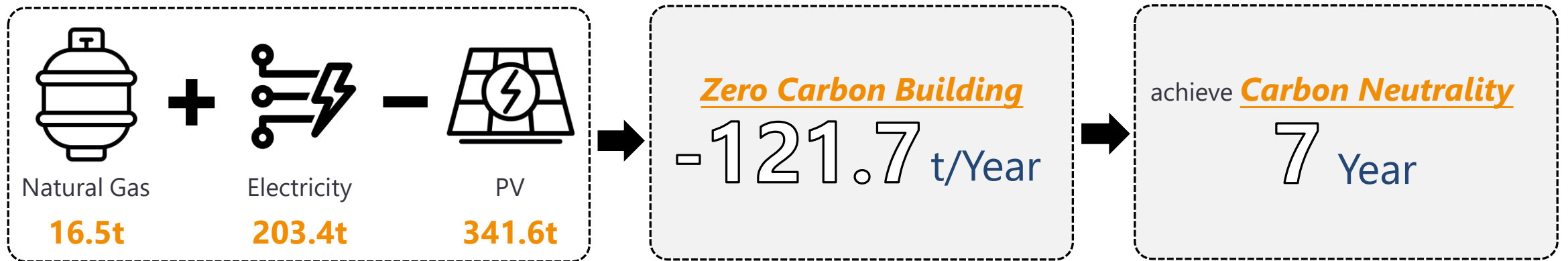
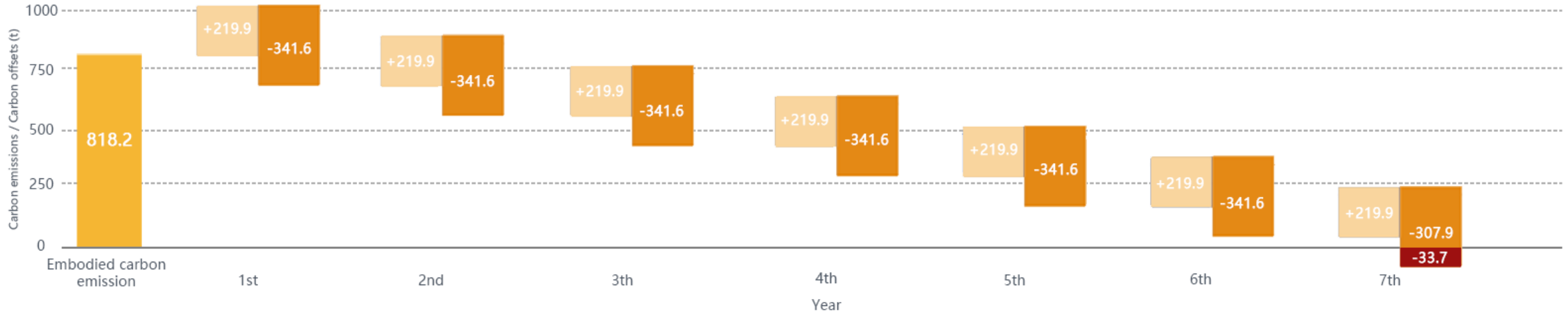
Community

Market

Trade-off



Carbon neutral calculation





Light Control

Intense noon sunlight poses risks to children's vision health
Excessive exposure to ultraviolet radiation presents health hazard

- Utilization of two layers of polymer heat-insulating film in the middle of the quadruple-pane triple-cavity glass at the solar corridor
- As the ultraviolet radiation intensifies in the noon sunlight, the glass adjusts its transparency accordingly

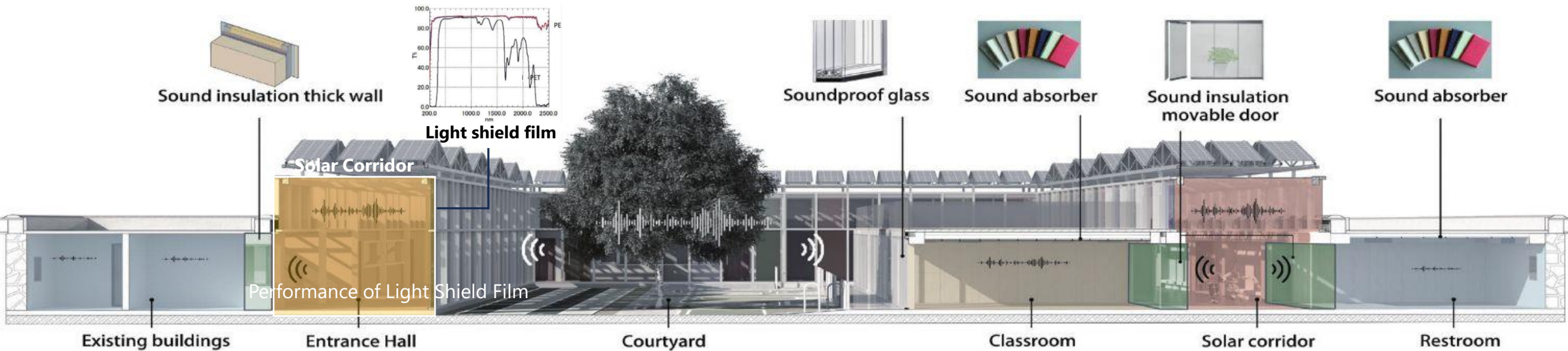
Acoustic Control

the main sources of noise: the inner courtyard / teaching activities / the solar corridor

Material performance considered in **decoration and enclosure structure design.**

Sound insulation materials chosen:

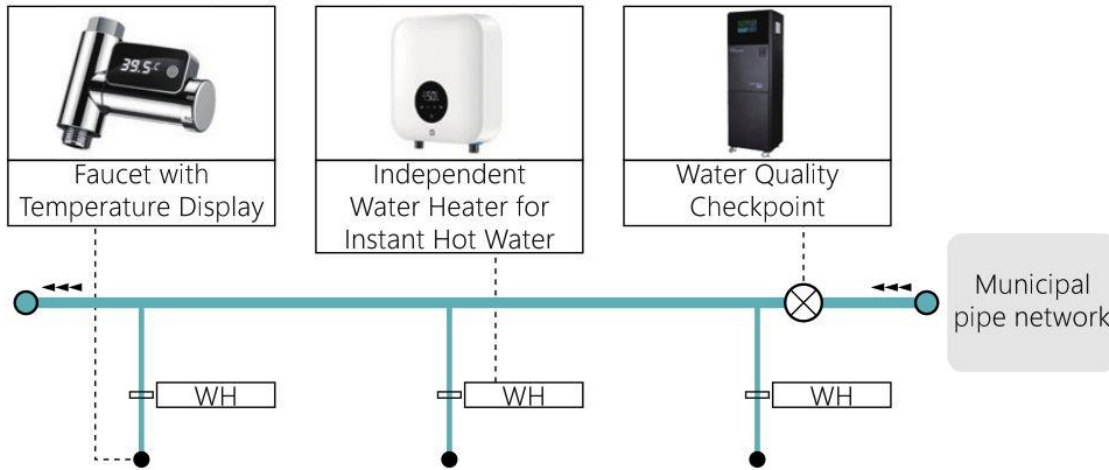
- Quadruple-glazed triple-cavity glass
- Straw decorative panels
- Hanging sound-absorbing bodies
- Sound-absorbing curtains



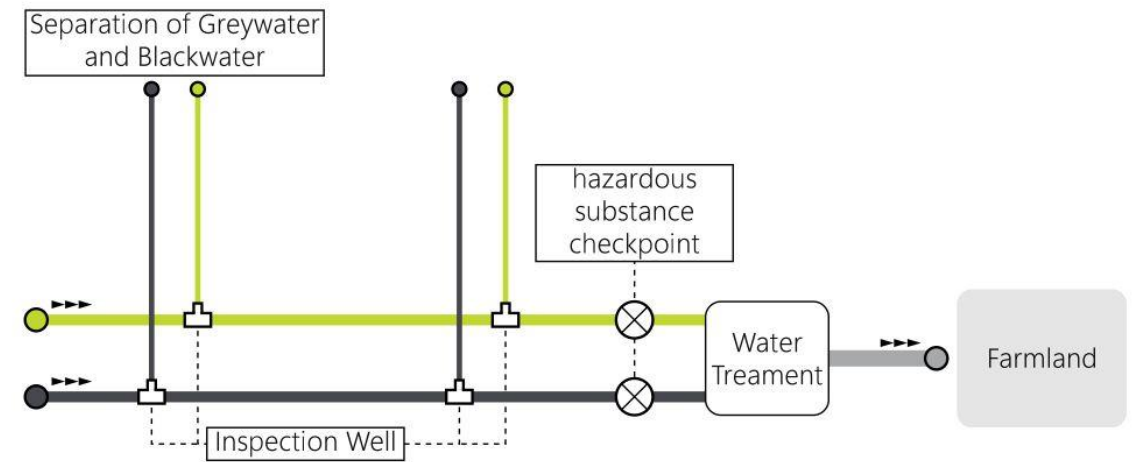


- Water quality checkpoints placed at the end of the pipeline network for safety
- Water temperature displayed at taps in children's areas
- Independent small electric water heaters at handwashing sinks for rapid hot water supply
- Emphasis on converting nitrogen and phosphorus in sewage to meet farmland standards in Tibet

Water Supply



Water Drainage



Measurements For Water Health

Air quality



Source control

- **Platinum-certified paint products** evaluated by the Chinese healthy building product assessment system
- **Environmentally friendly** rubber material
- Solid wood furniture with relatively **low levels of formaldehyde and VOCs**



Rubber floor

Natural rubber products



Wood furniture

Natural wood products



Formaldehyde-free paint

Add bamboo charcoal to adsorb pollutants



EBP Straw board

Straw compression molding, formaldehyde free

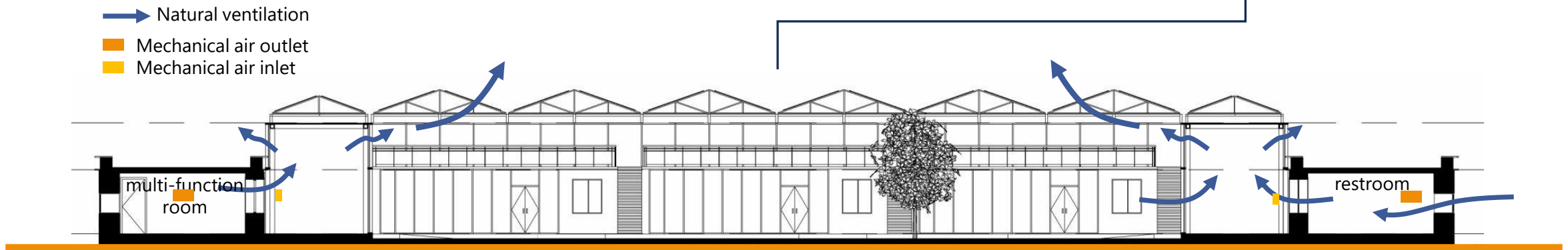
Pathway control

- Combination of **passive and active** ventilation
- Installation of **PM2.5 filters** on ducts of the fresh air system

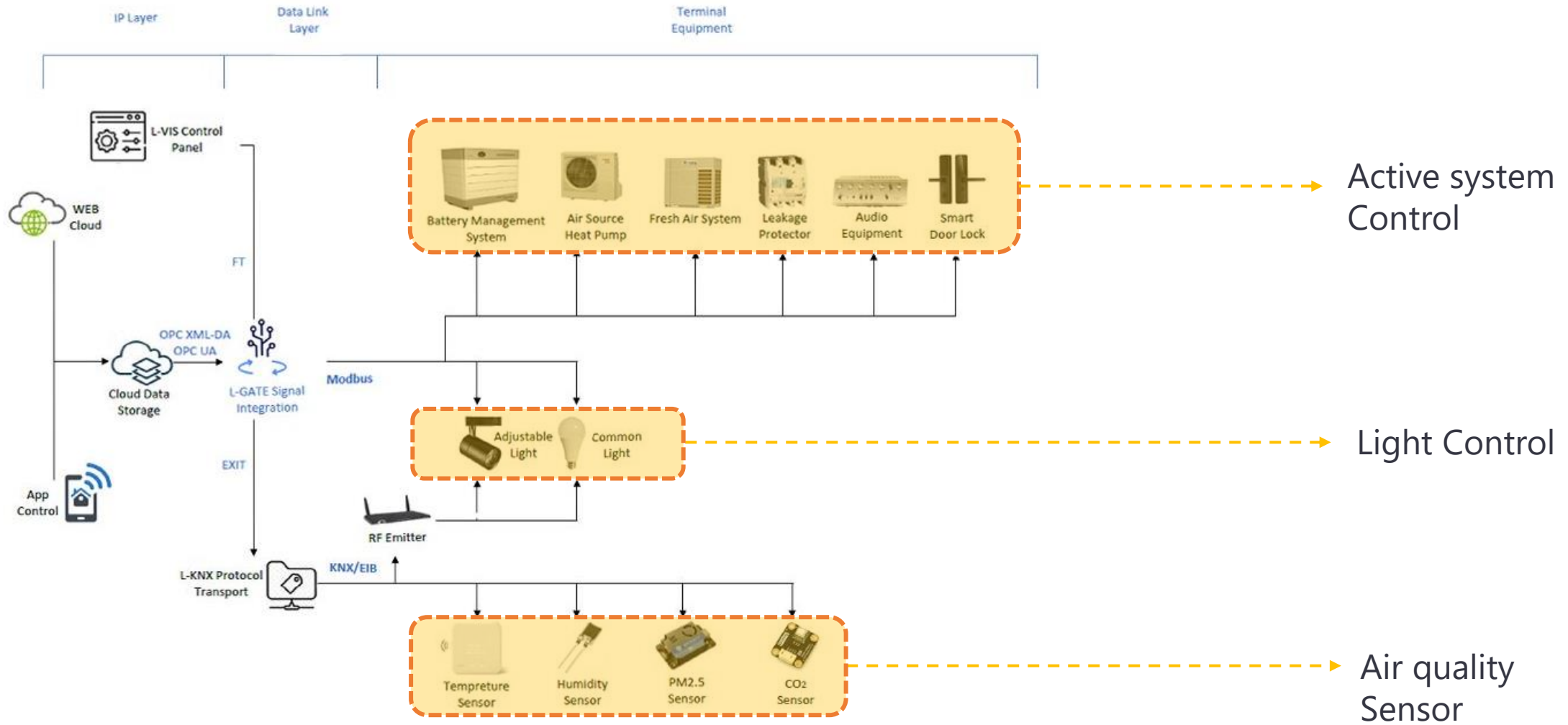
→ Natural ventilation

■ Mechanical air outlet

■ Mechanical air inlet



Control system



Engagement of community

Kindergarten in Sangga-Education Division

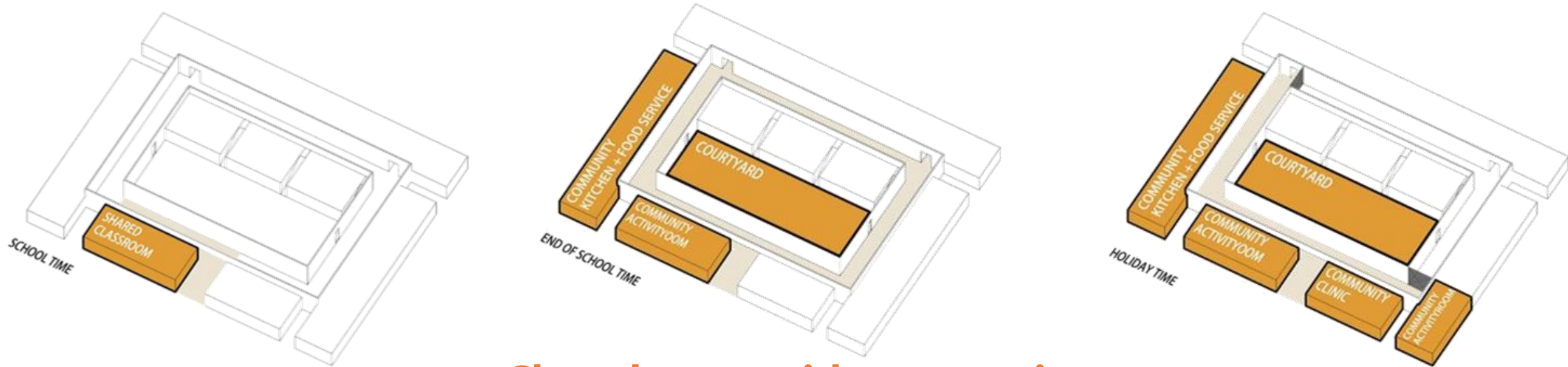


Demand

- Revitalizing the biggest courtyard village in the building
- Transition of low-income traditional agriculture
- Sewage treatment facilities
- Clean energy systems with higher efficiency



Interaction



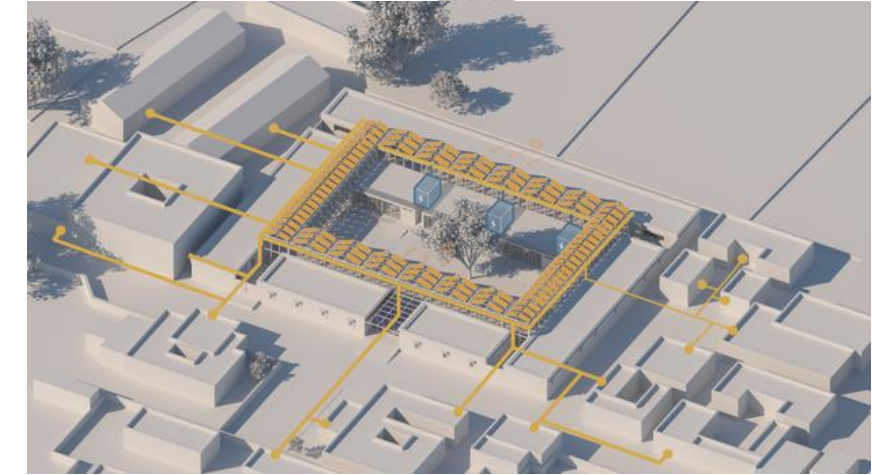
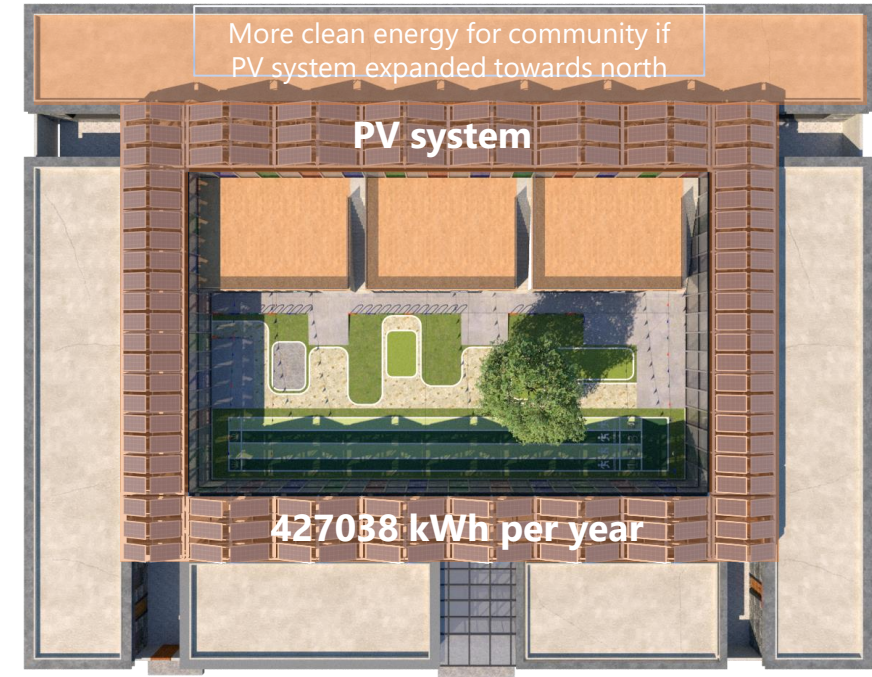
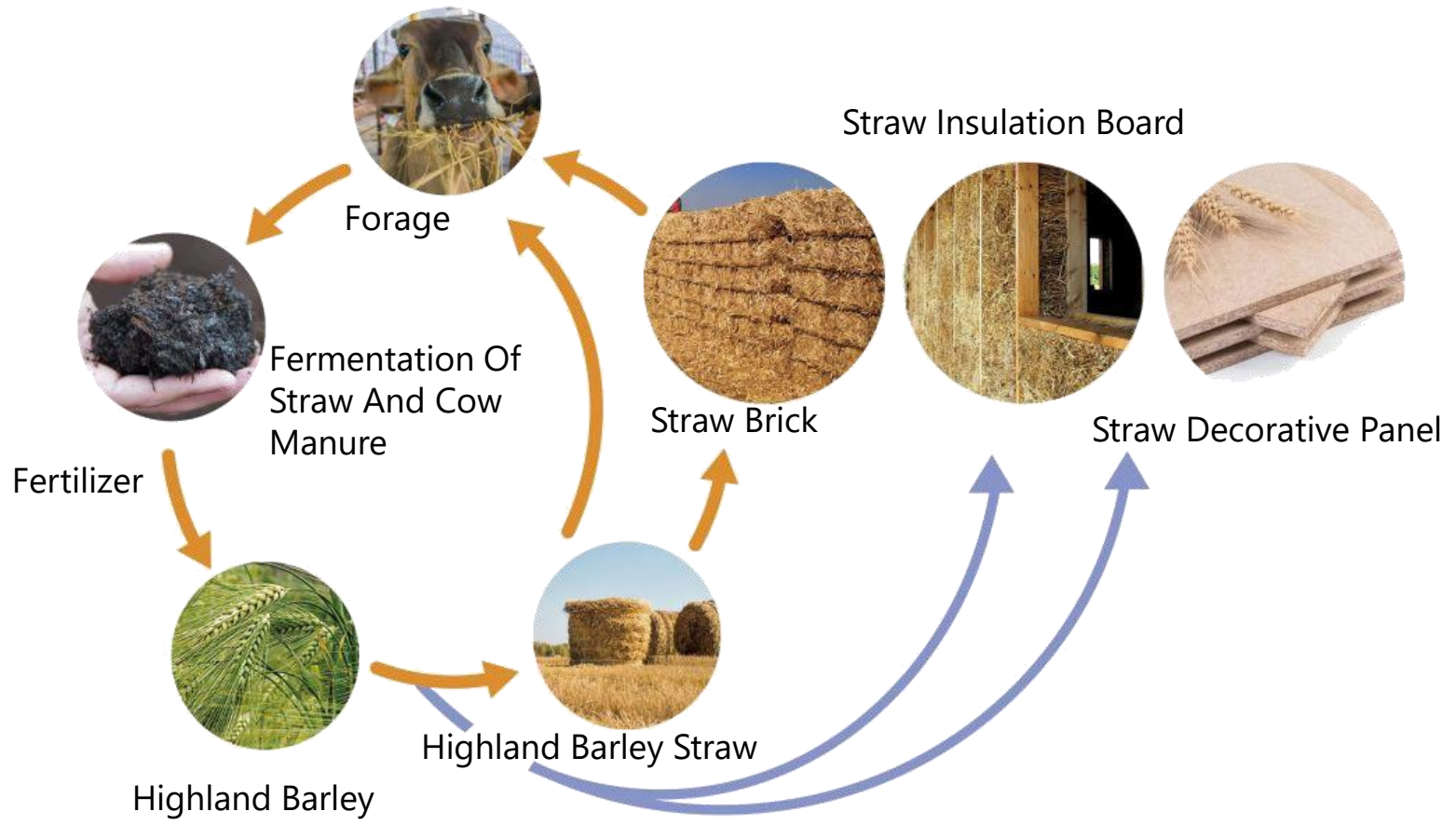
Shared space with community

Equity Promotion



Natural resource recycling and utilization

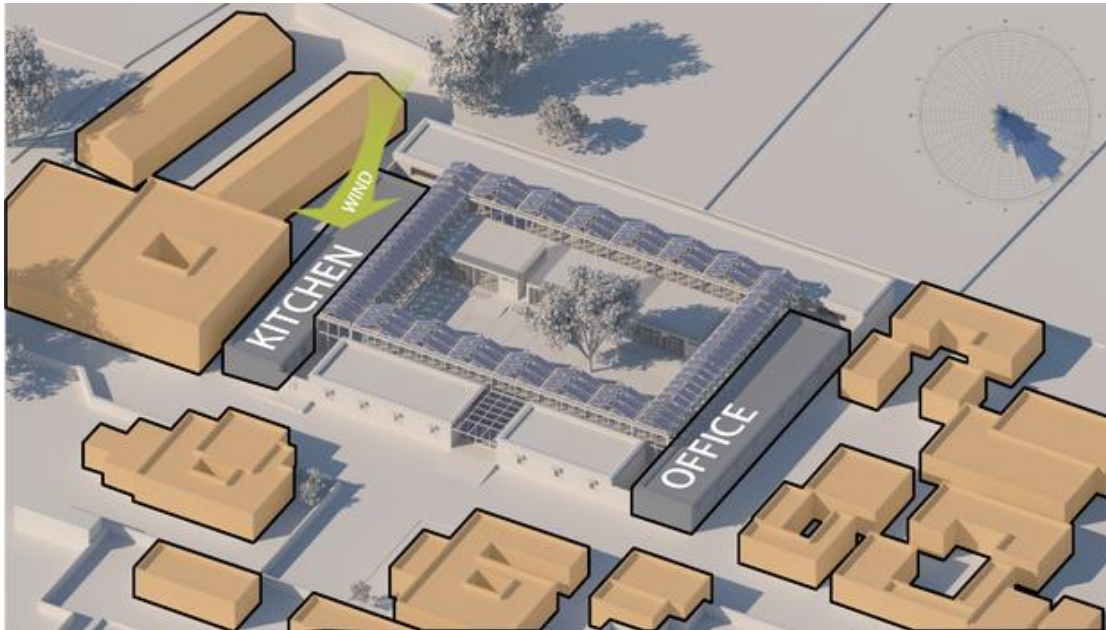
Highland Barley Straw cycle



Potential risk

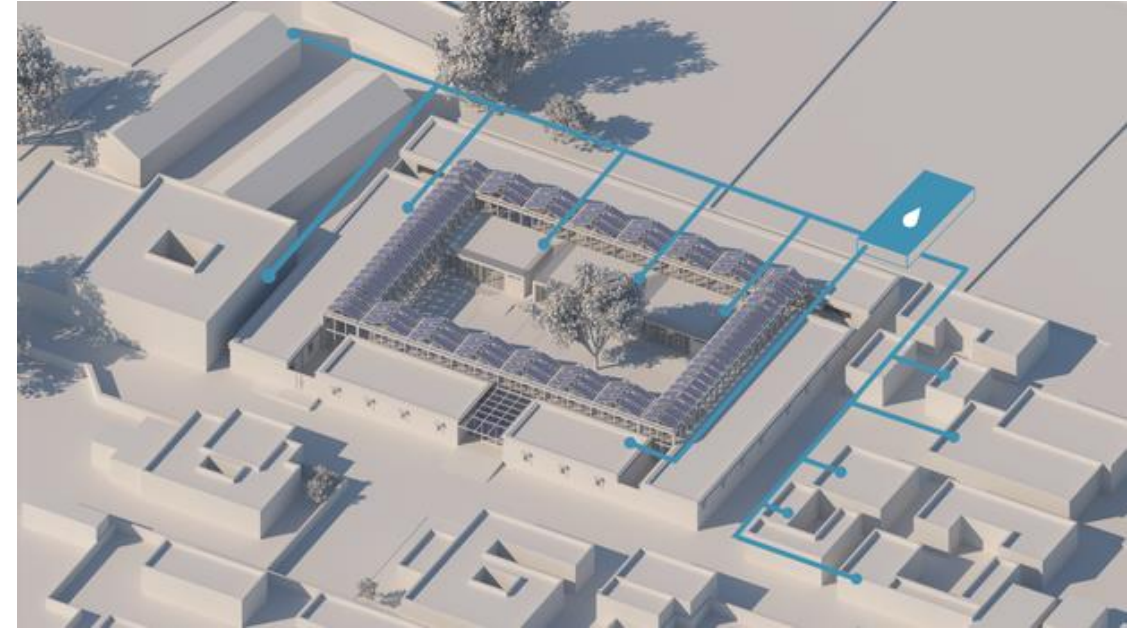


01 Noise and cooking fumes



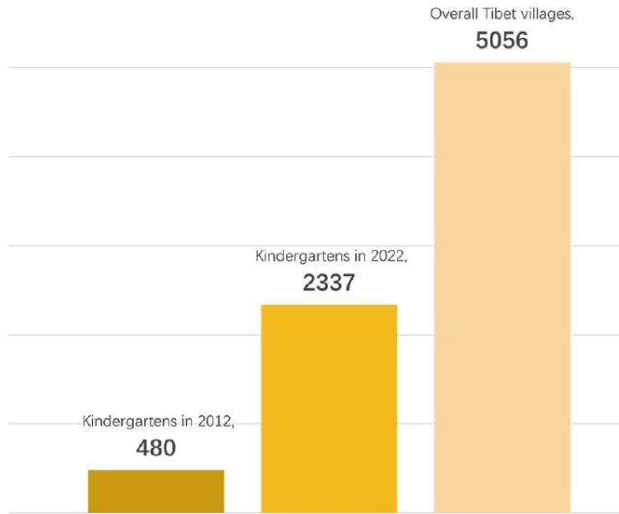
Function layout

02 Water pollution



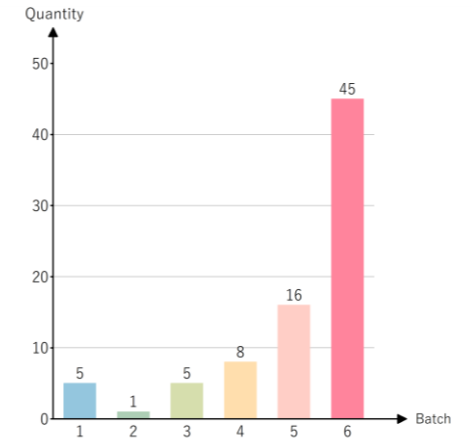
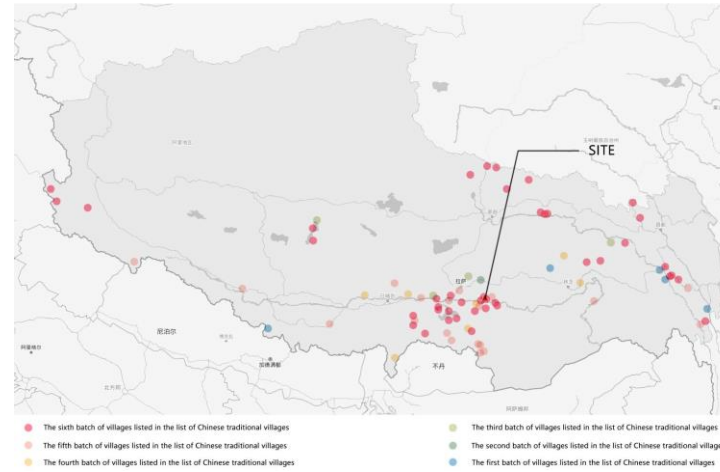
Shared sewage treatment

Market analysis



OVER 50% of villages in Tibet don't have their own kindergartens

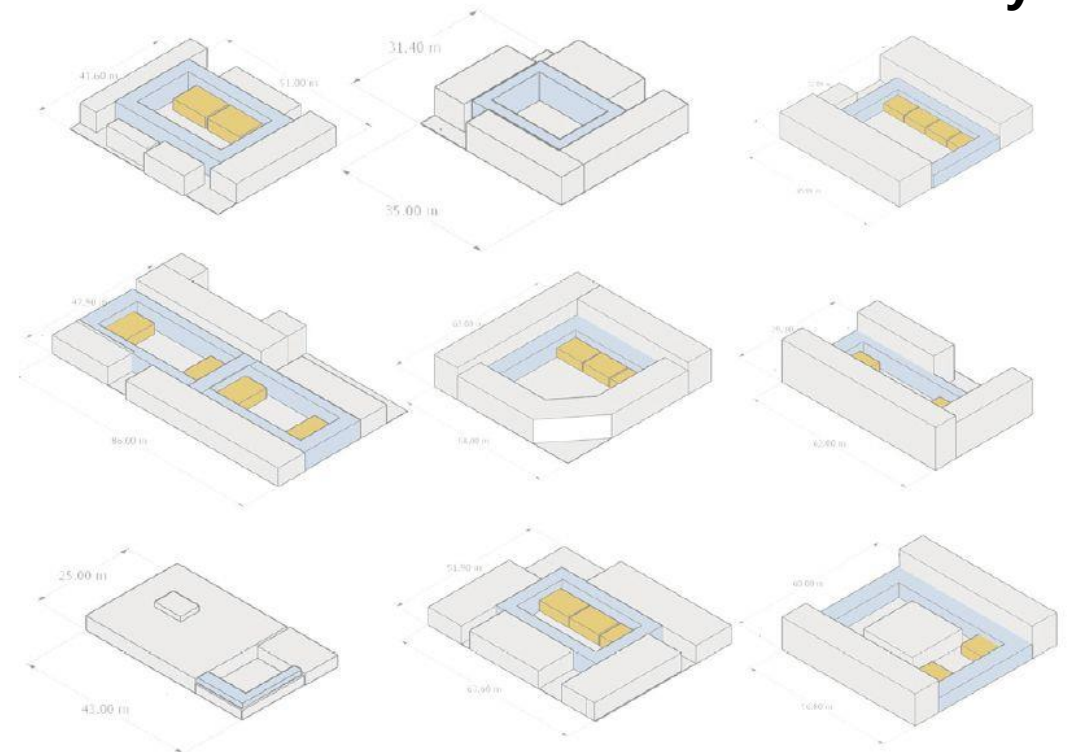
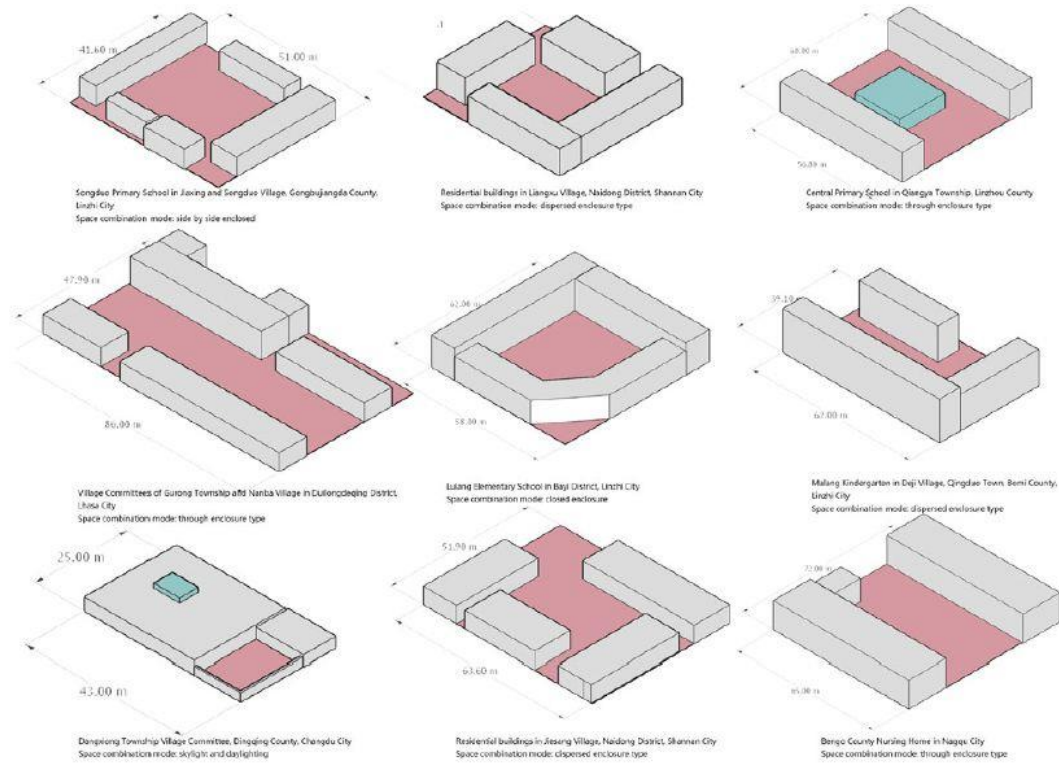
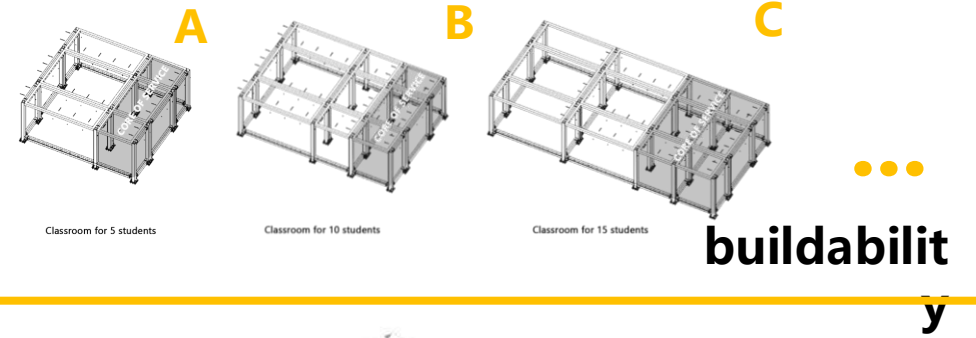
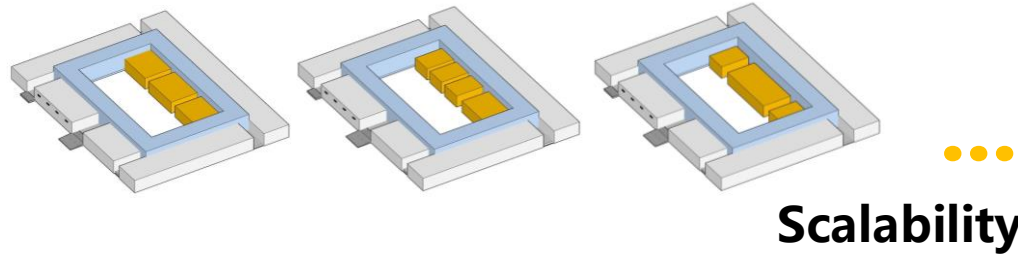
Lack of kindergartens



Increasing Tibetan villages in government's **revitalization plan**, calling for retrofit of misused public buildings.

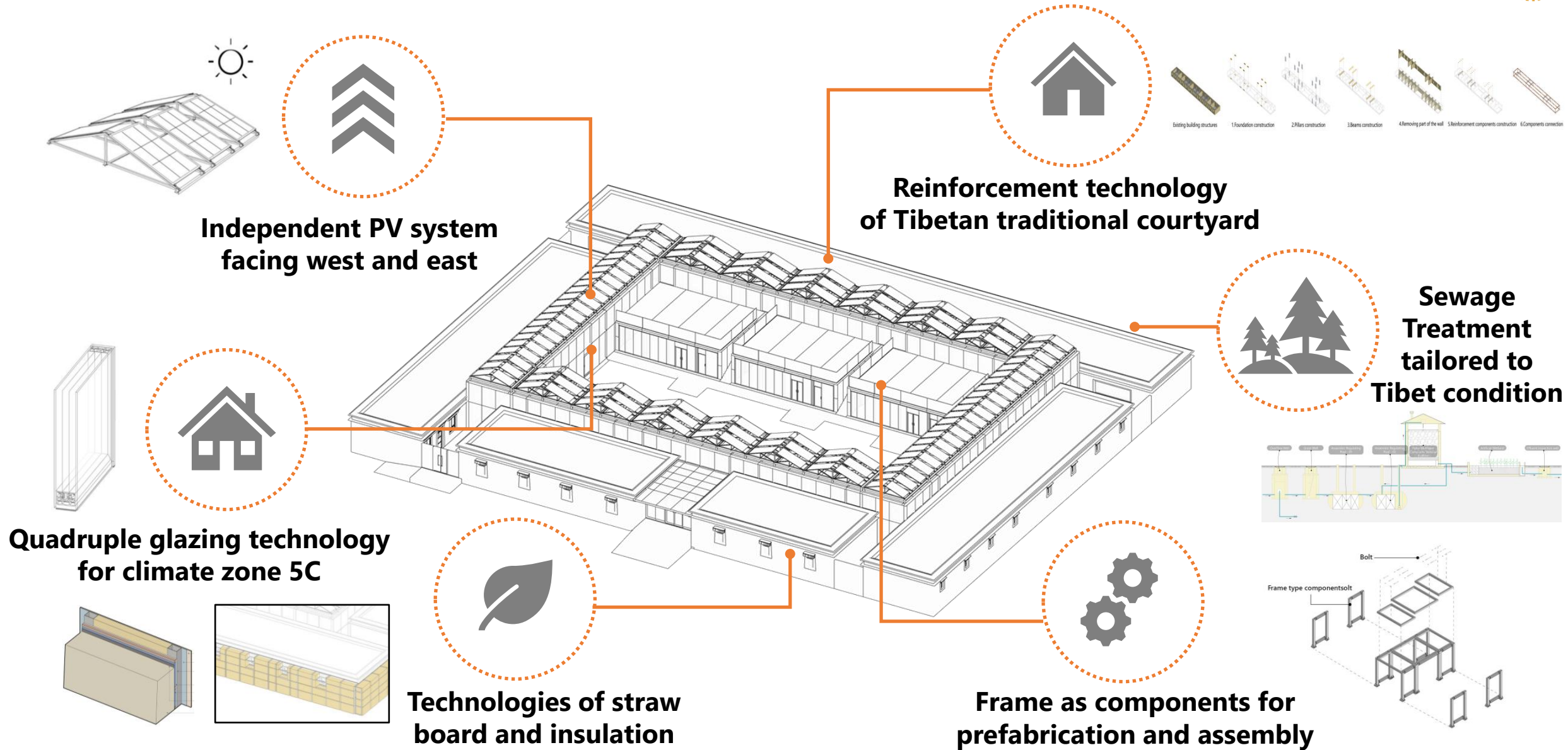
Demand of village revitalization

Market potential



Applied technology

Kindergarten in Sangga-Education Division



Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Community

Market

Cost estimation



Total Cost:

6,600,900 CNY
912,614 USD

Construction Cost:

5,170,180 CNY
714,808 USD

Retrofit Saved Cost:

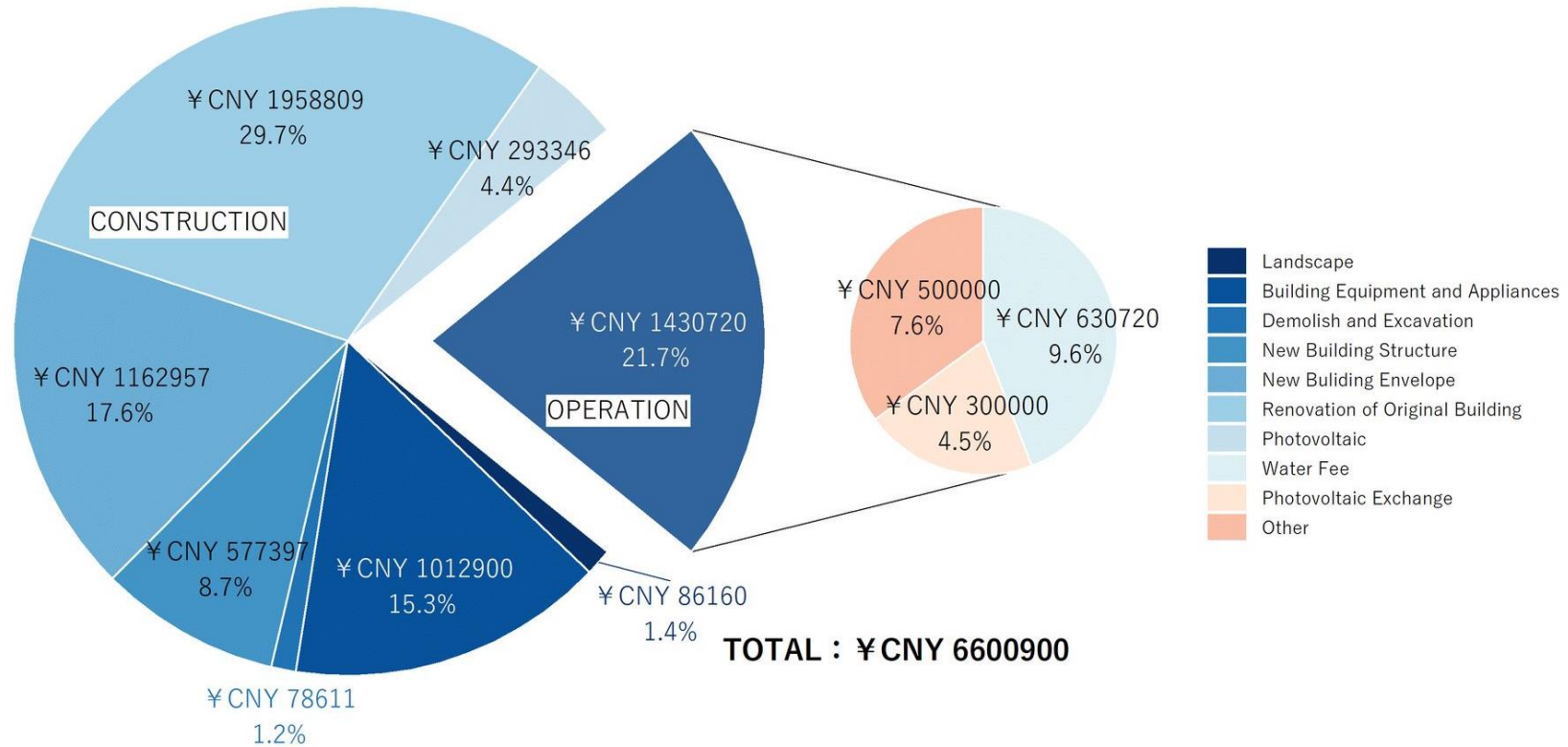
3,000,000 CNY
414,768 USD

Operation and Maintenance Cost:

1,430,720 CNY
197,806 USD

Average Utility Cost:

Cost w/o PV: \$ 1430.8/month
Cost w/ PV: \$ -540.33/month



Project Budget Pie Chart

Engagement of industry

Kindergarten in Sangga-Education Division



Research Academy+
Cooperative enterprises



Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Community

Market

Solar Ark

ཉམ་གཤིས་སྤྱི་ལུ་སྤྱི་ལུ་



Thanks everyone for listening!

You are welcomed to scan the QR code for more information.

Appendix 1:EUI Calculation



Program	Thermal zone	Occupancy density (m ² /p)	Lighting density (W/m ²)	Equipment density (W/m ²)	Heating			Flow rate (m ³ /s·m ²)	Air change rate (1/hr)	Schedule			
					setpoint (°C)	COP	Max supply air (°C)						
Activity room	1	10	8	5	20	4	50	0	4	8am-19pm			
Dining room													
Multifunctional room													
Office													
Meeting room													
Library	2		6		4.5				20		24	20	4
Corridor													
Lobby													
Kitchen													
Storeroom													
Guard room	3	8	8	20	20	0.00176	4						
Toilet													
Bedroom													
Health room	6	13.5	13.5	20	20	0.00139	4						
Art room													

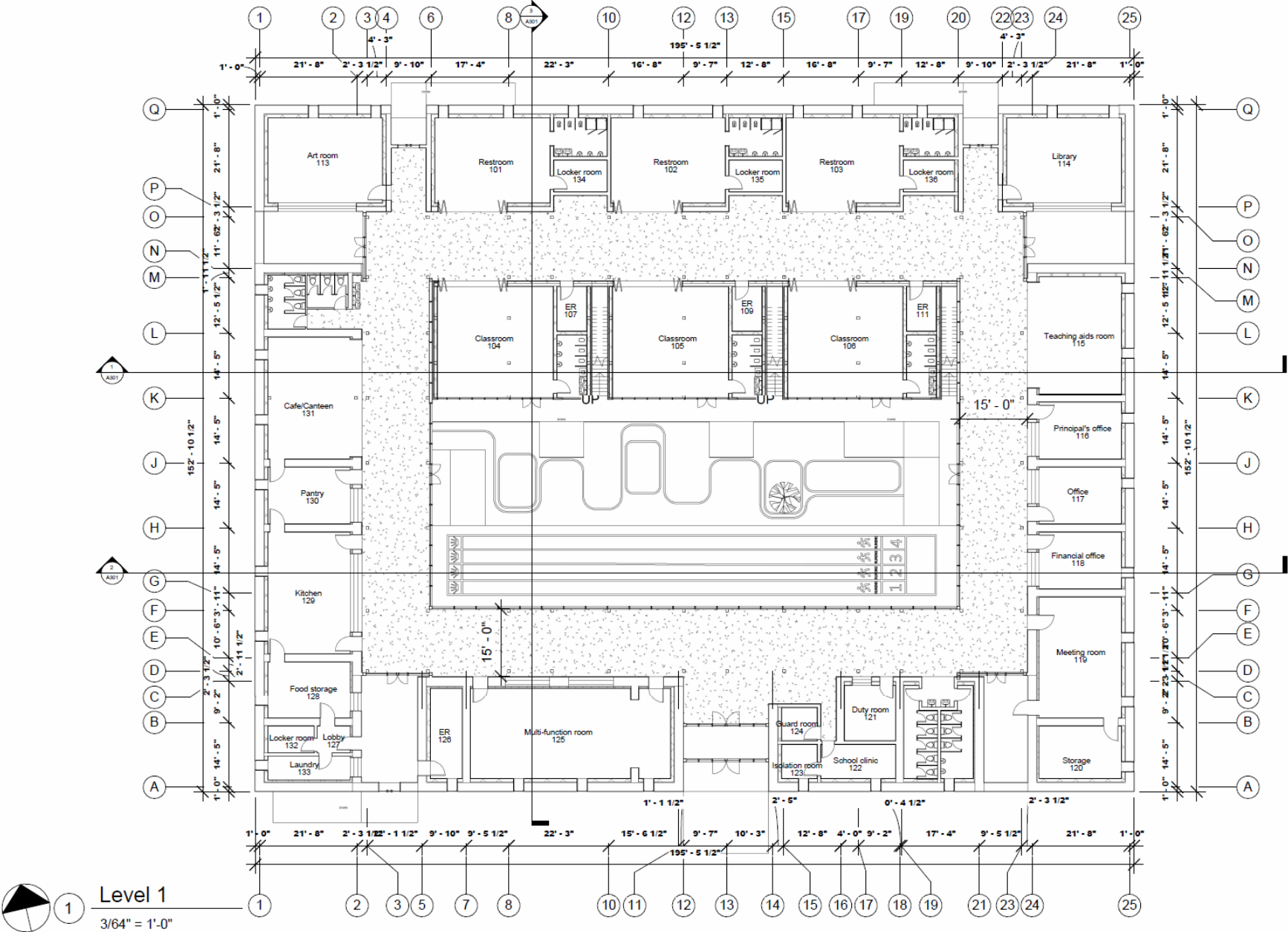
Appendix 2: Carbon emission calculation



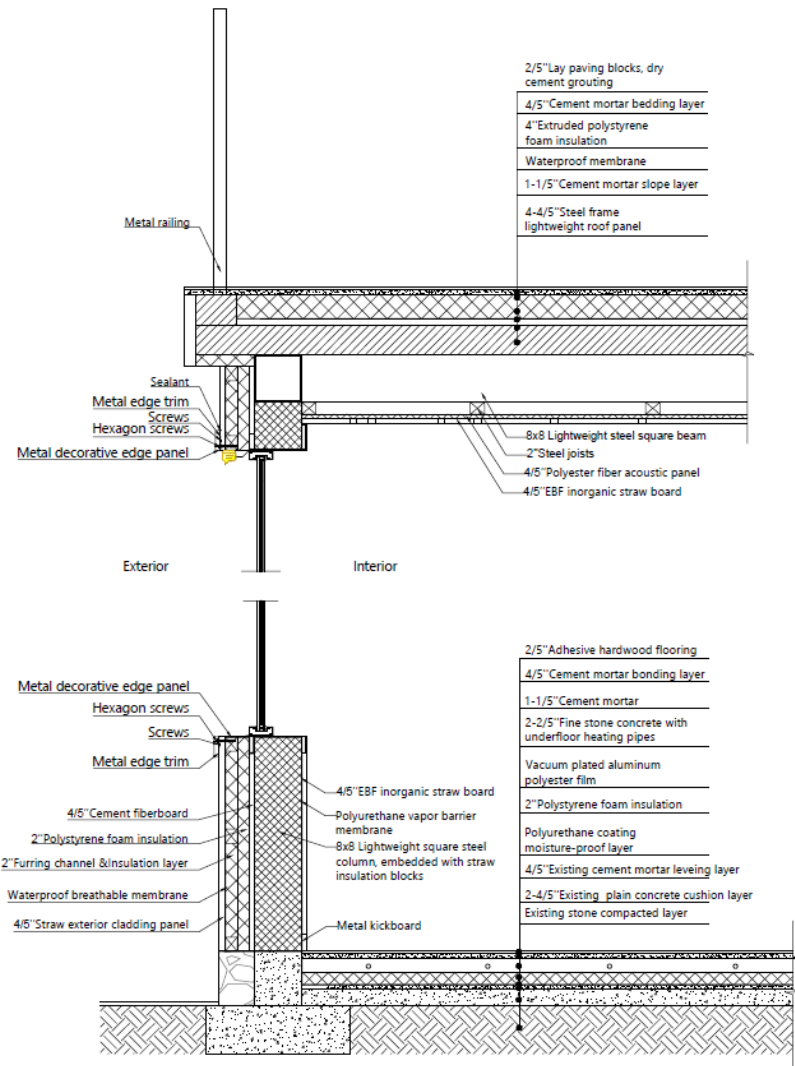
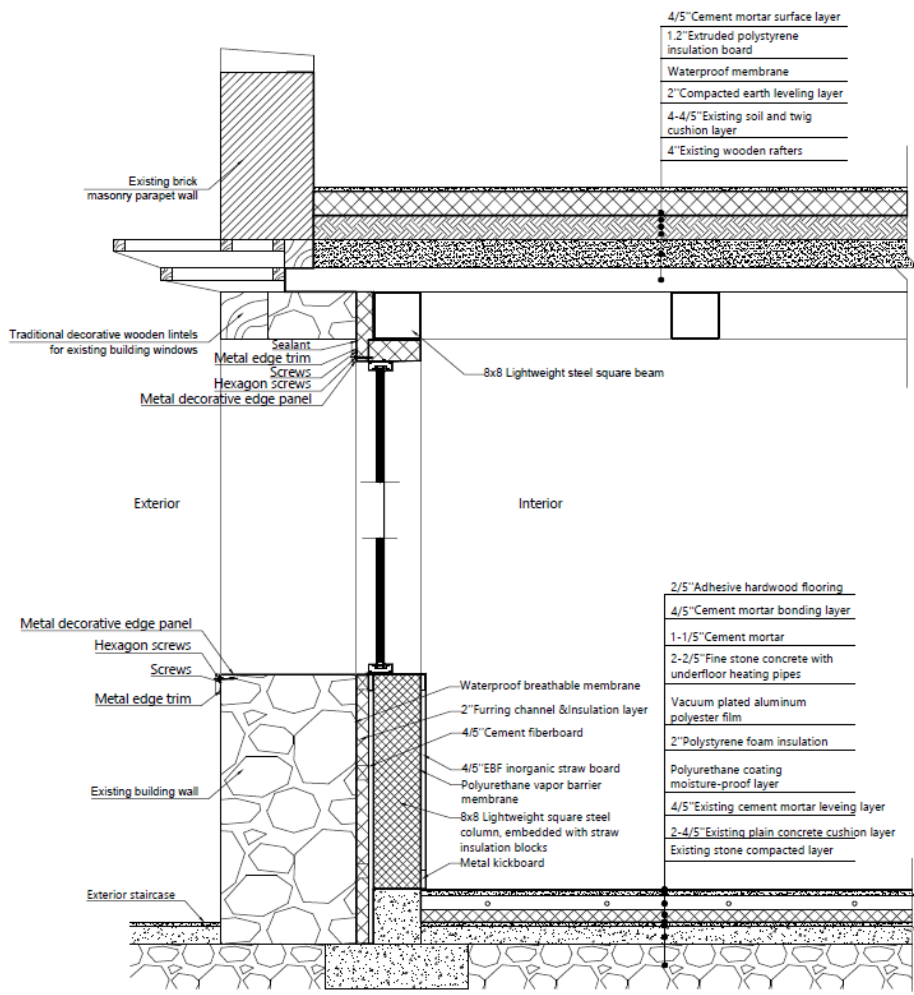
Life-Cycle assessment for level(s) in compliancy with EN 15978

Section	Result category	Global warming kg CO2e
A1-A3	Construction Materials	4.16E+05
A4	Transportation to site	1.54E+04
A5	Construction/installation process	6.10E+04
B1	Use phase	5.17E+02
B4-B5	Material replacement and refurbishment	3.64E+05
B6	Energy consumption	1.32E+07
B7	Water use	6.70E+04
C1-C4	End of life	1.39E+04
D	External impacts (not included in totals)	-2.13E+07
Total		1,41E+07

Appendix 3: Construction drawings



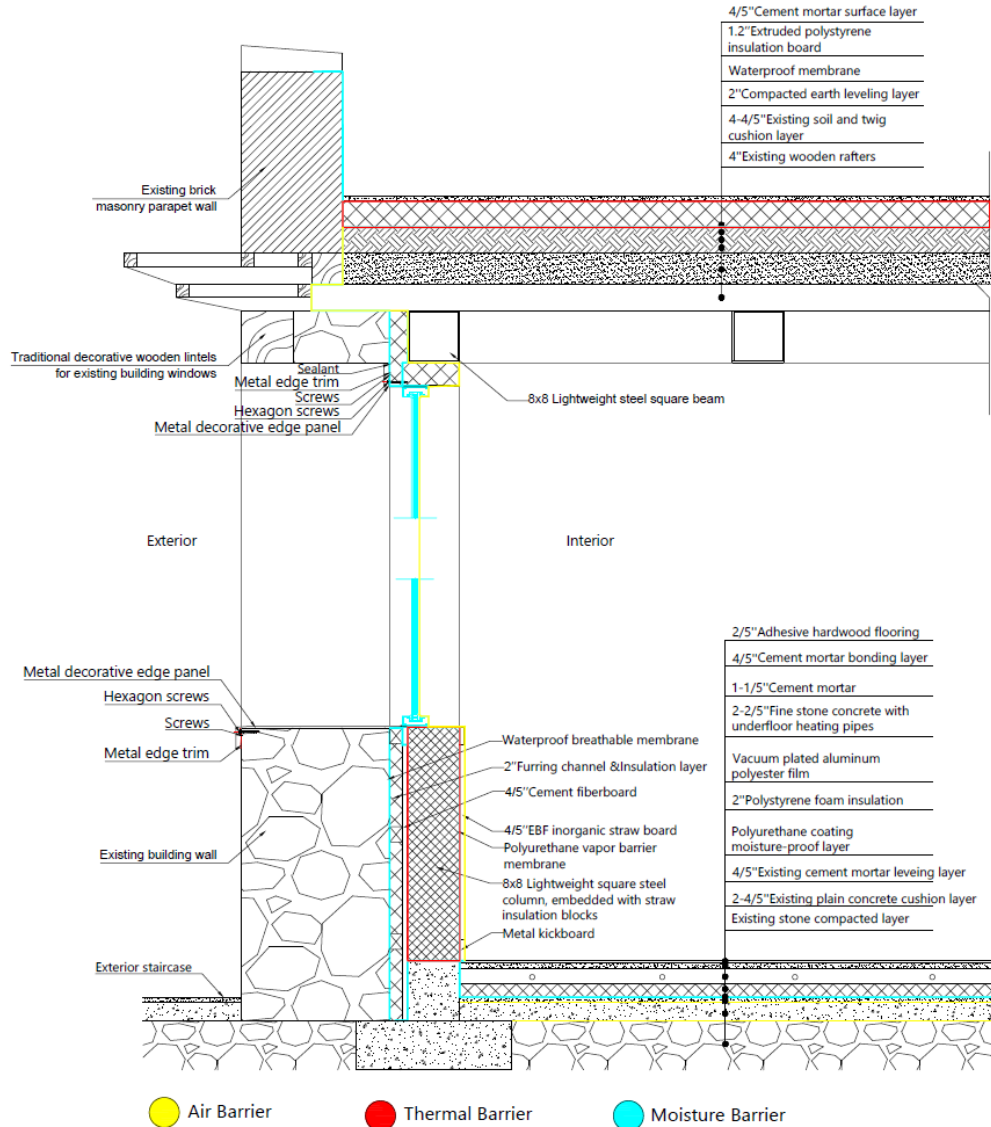
Appendix 3: Construction drawings



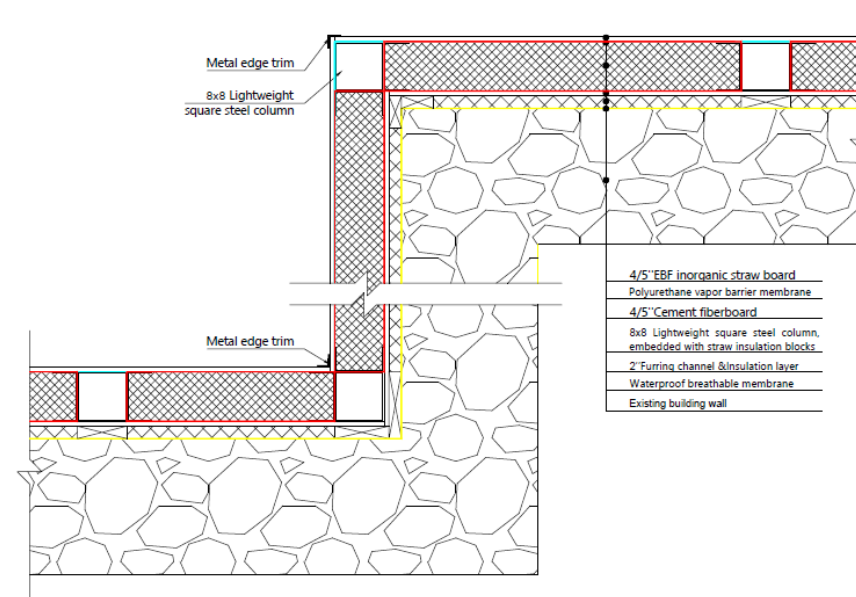
1 Renovation Existing Wall Section
2/3" = 1'-0"

2 Prefabricated Wall Section
2/3" = 1'-0"

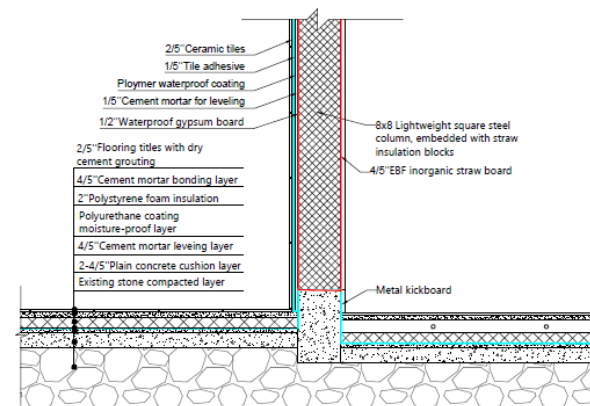
Appendix 3: Construction drawings



3 Control Layer Detail
2/3" = 1'-0"



4 Renovated Existing Wall Section
2/3" = 1'-0"



5 Floor Detail
2/3" = 1'-0"