SUNFLOWER 46: REBUILDING HOPE

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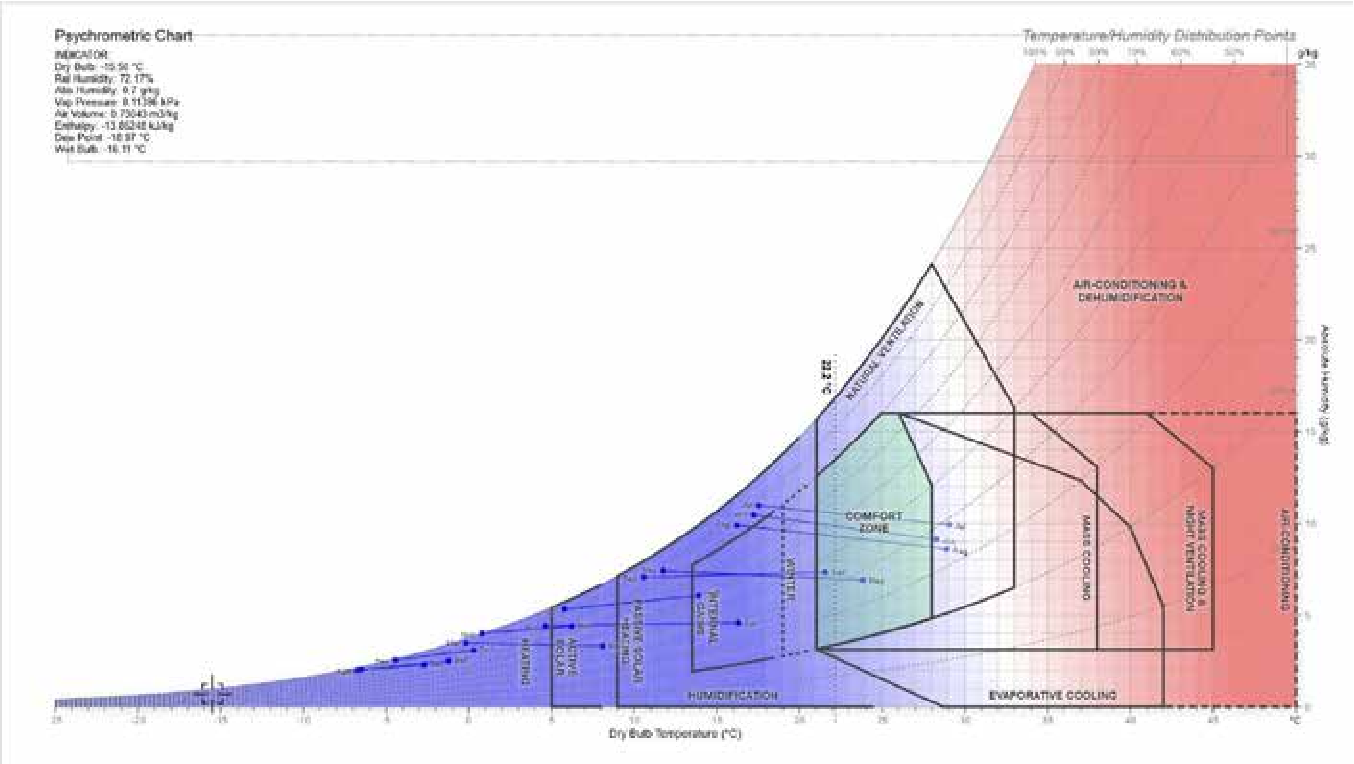
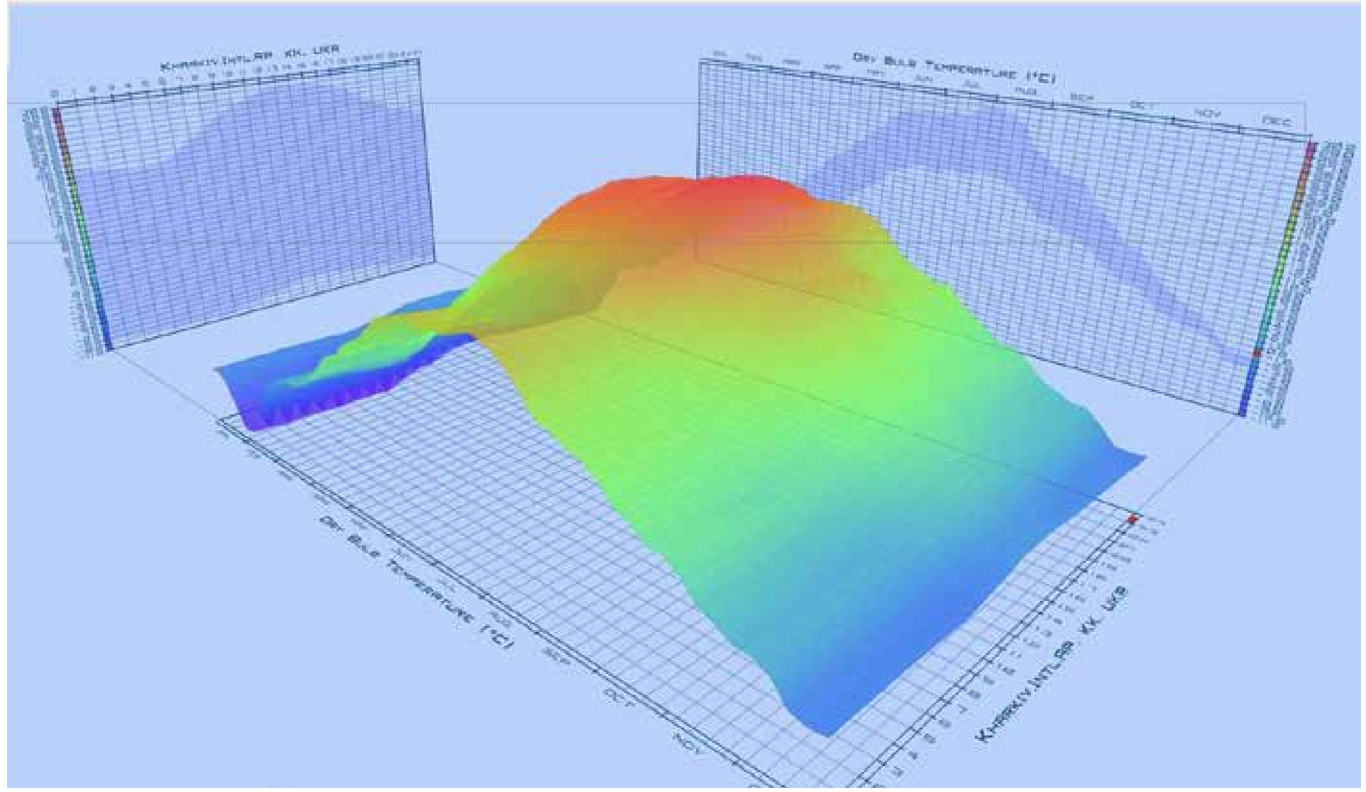
PROJECT OVERVIEW

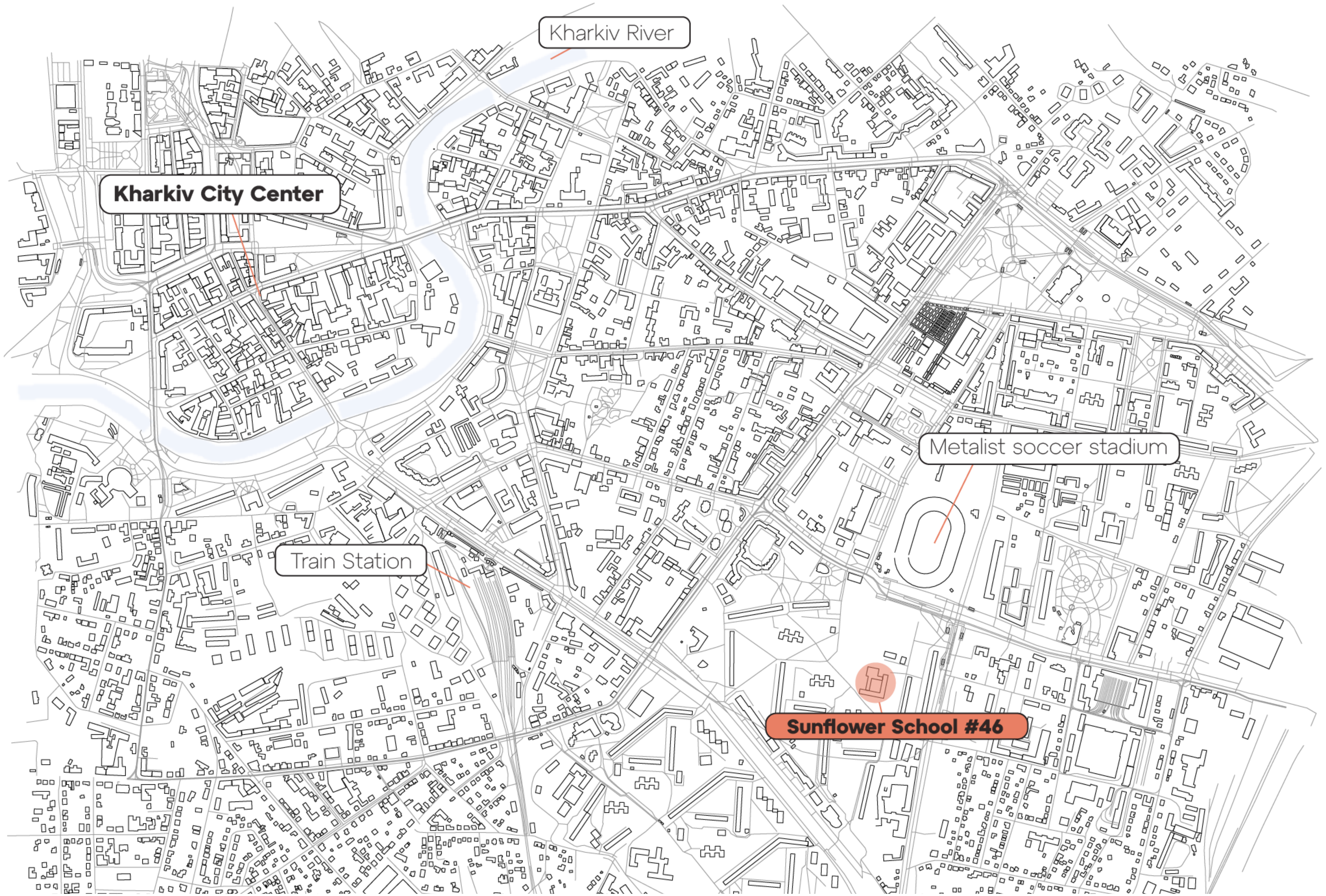
Ukraines Second Largest City	Population of 1.4 Million
Located	25 Miles From Russian Boarder
Schools Damaged in War	2,600
Average Age	35



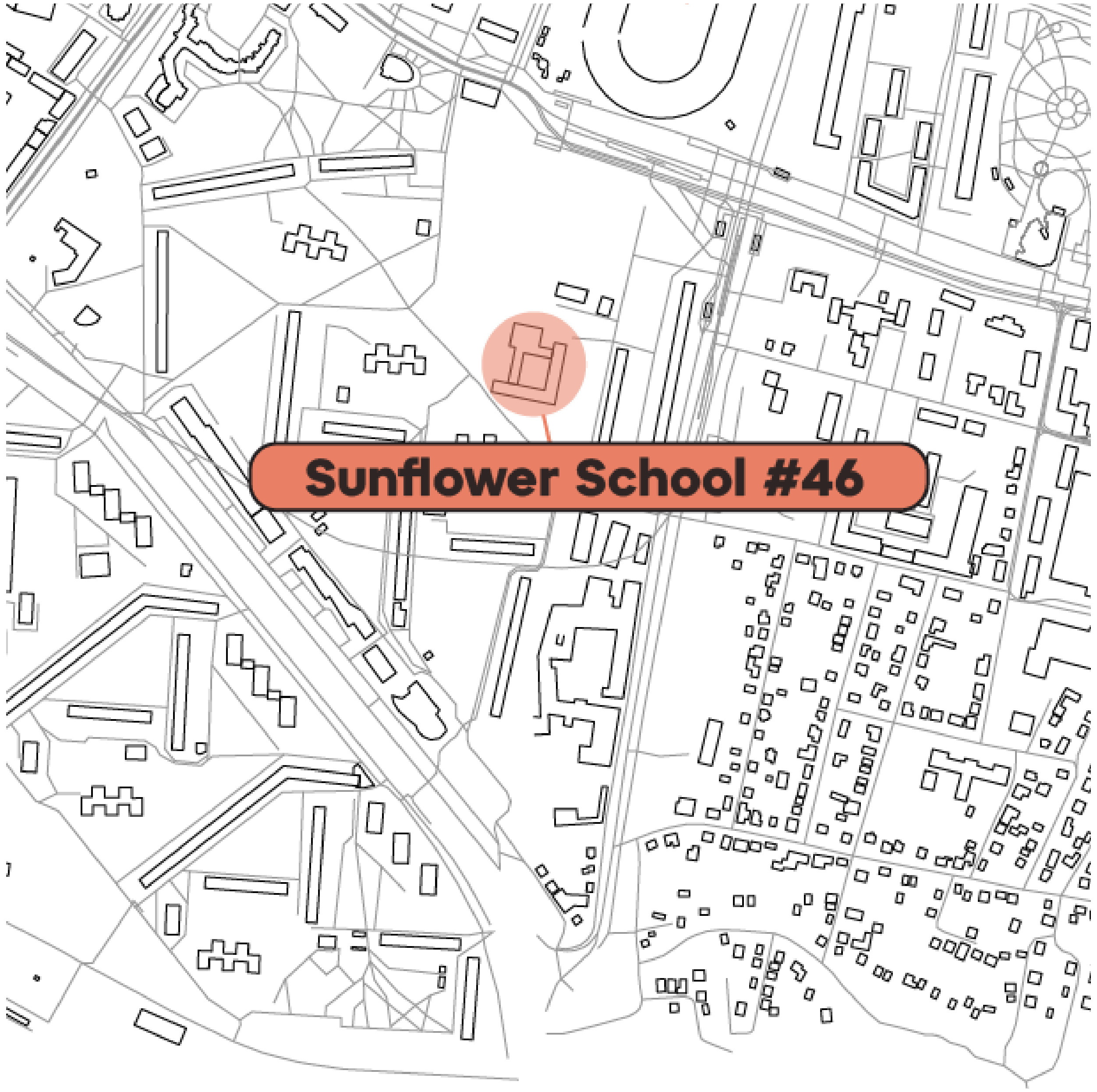
Climate (Zone 5A)

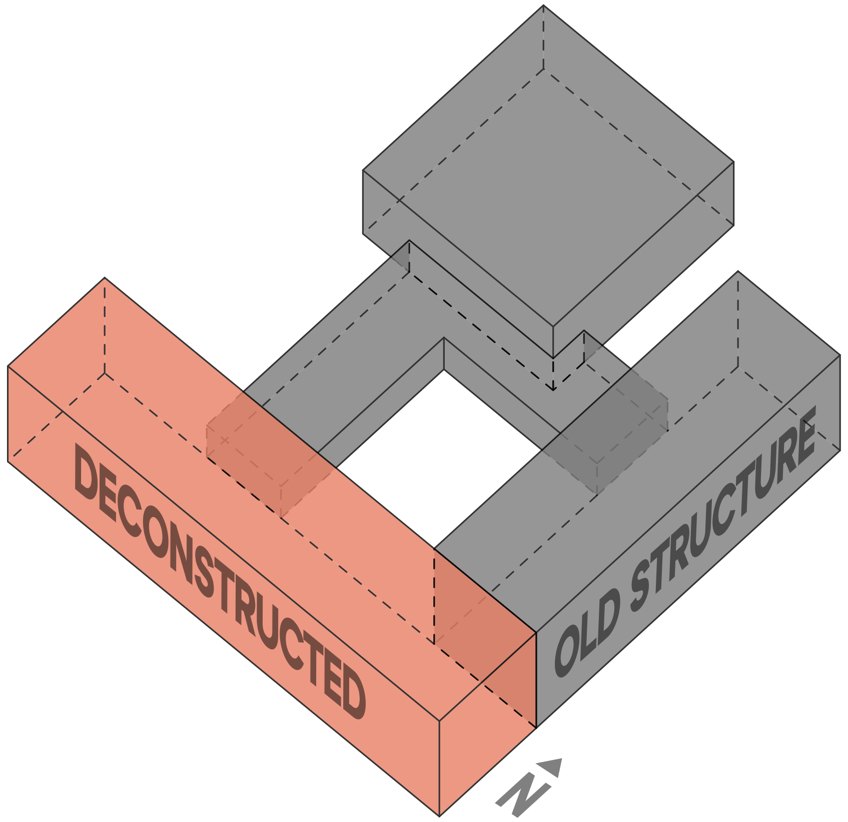
Location	Kharkiv, Ukraine
Climate Zone	5A
Elevation	500' / 152 meters
Mean Temp	47 degrees F
Heating Degree Days	4955
Cooling Degree Days	840



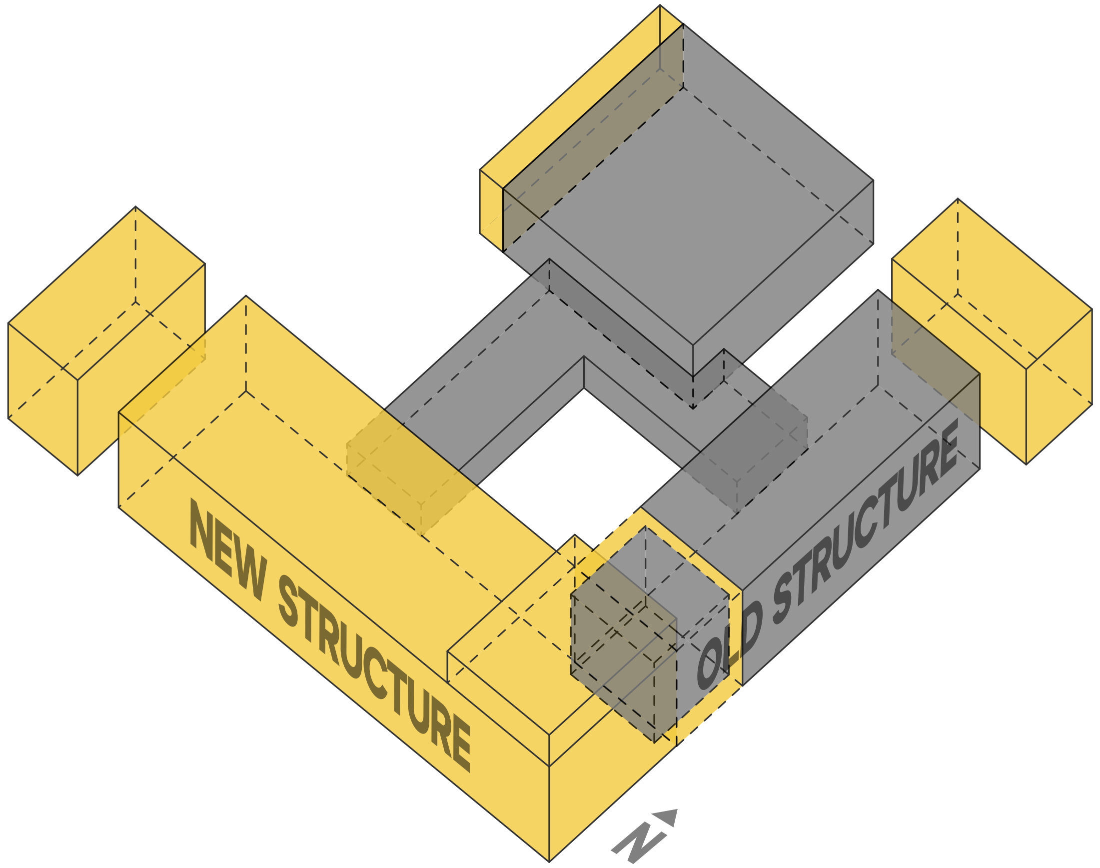

Kharkiv River
Kharkiv City Center
Metalist soccer stadium
Train Station
Sunflower School #46

The south wing of Kharkiv School #46 was destroyed beyond repair. The remainder of the school is still intact, with its original concrete post-and-beam construction.





VS



OLD

PRESERIVING THE OLD BUILDING SAVED **86 MILLION MBTU**.
WE ALSO DECONSTRUCTED THE DESTROYED BUILDING AND
REUSED RUBBLE IN FLOOR SLABS AND PLANTER BOXES.

NEW

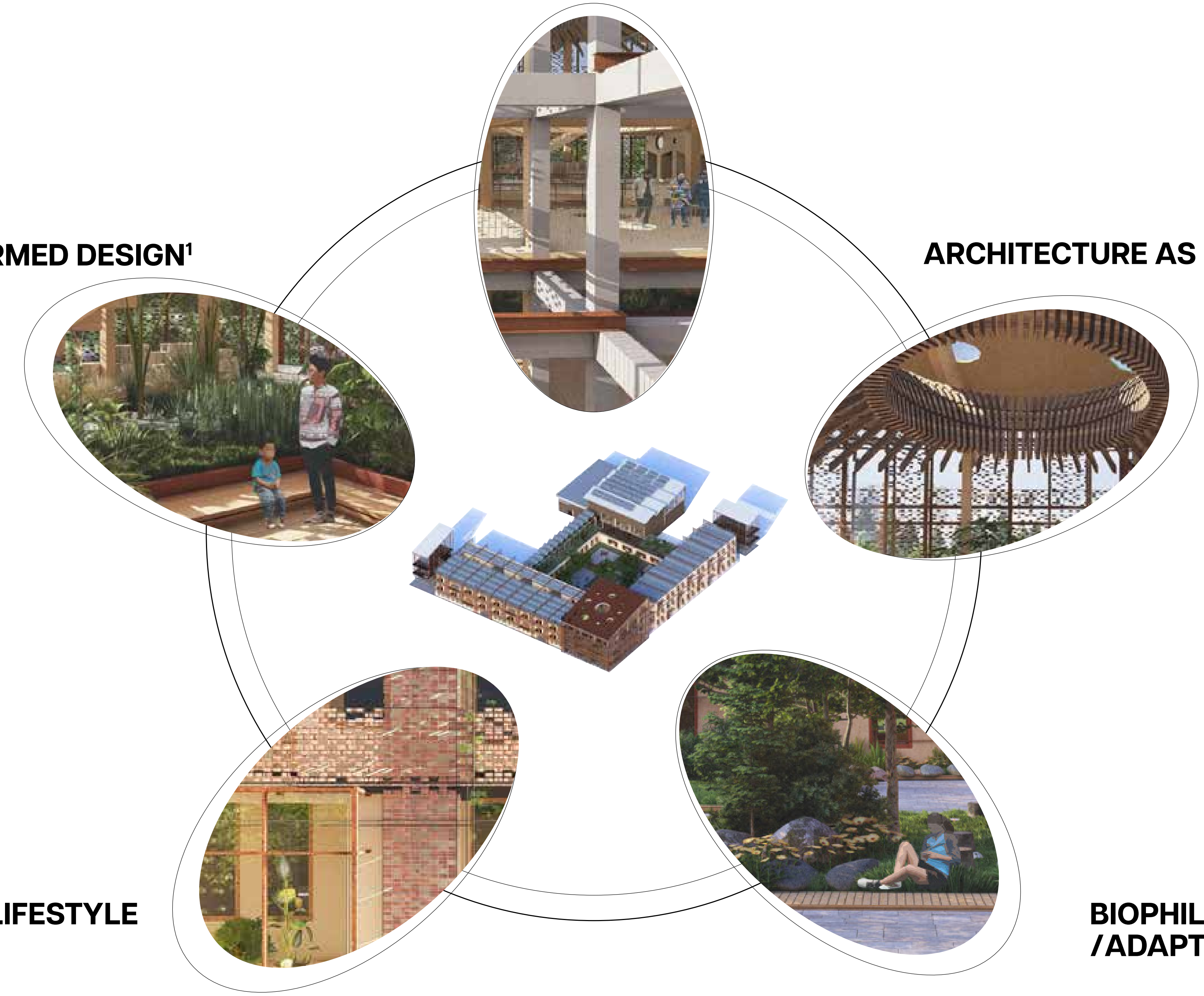
26 MILLION MBTU WAS SAVED BY USING SUSTNABLE BUILDING
MATERIALS SUCH AS **FLYASH CONCRETE** AND **MASS TIMBER**

DESIGN PRINCIPLES

CULTURAL MATERIAL RECOVERY[2]

TRAUMA-INFORMED DESIGN[1]

ARCHITECTURE AS THE THIRD TEACHER[3]



SUSTAINABLE LIFESTYLE

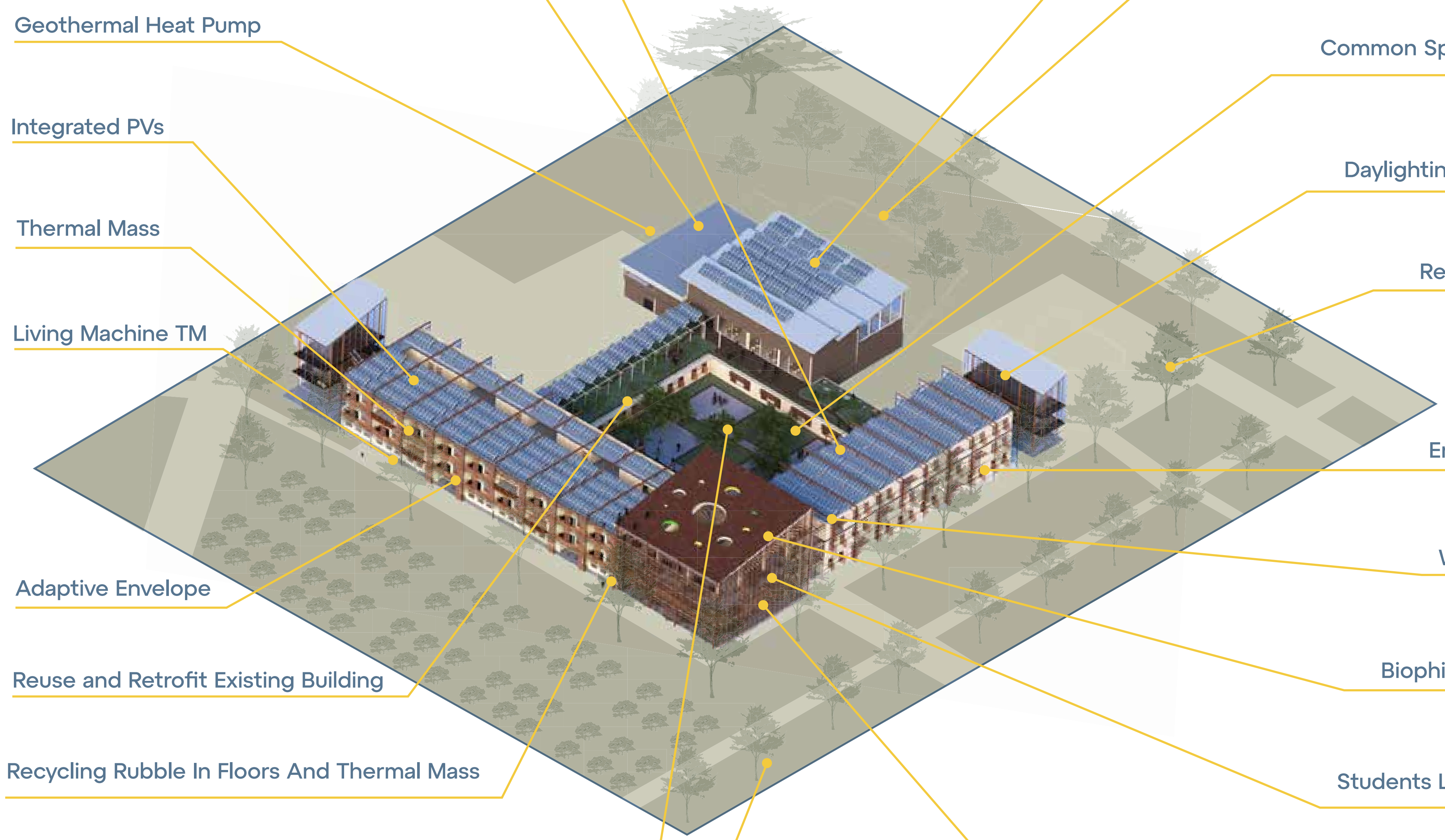
BIOPHILIC DESIGN[4] /ADAPTIVE COMFORT

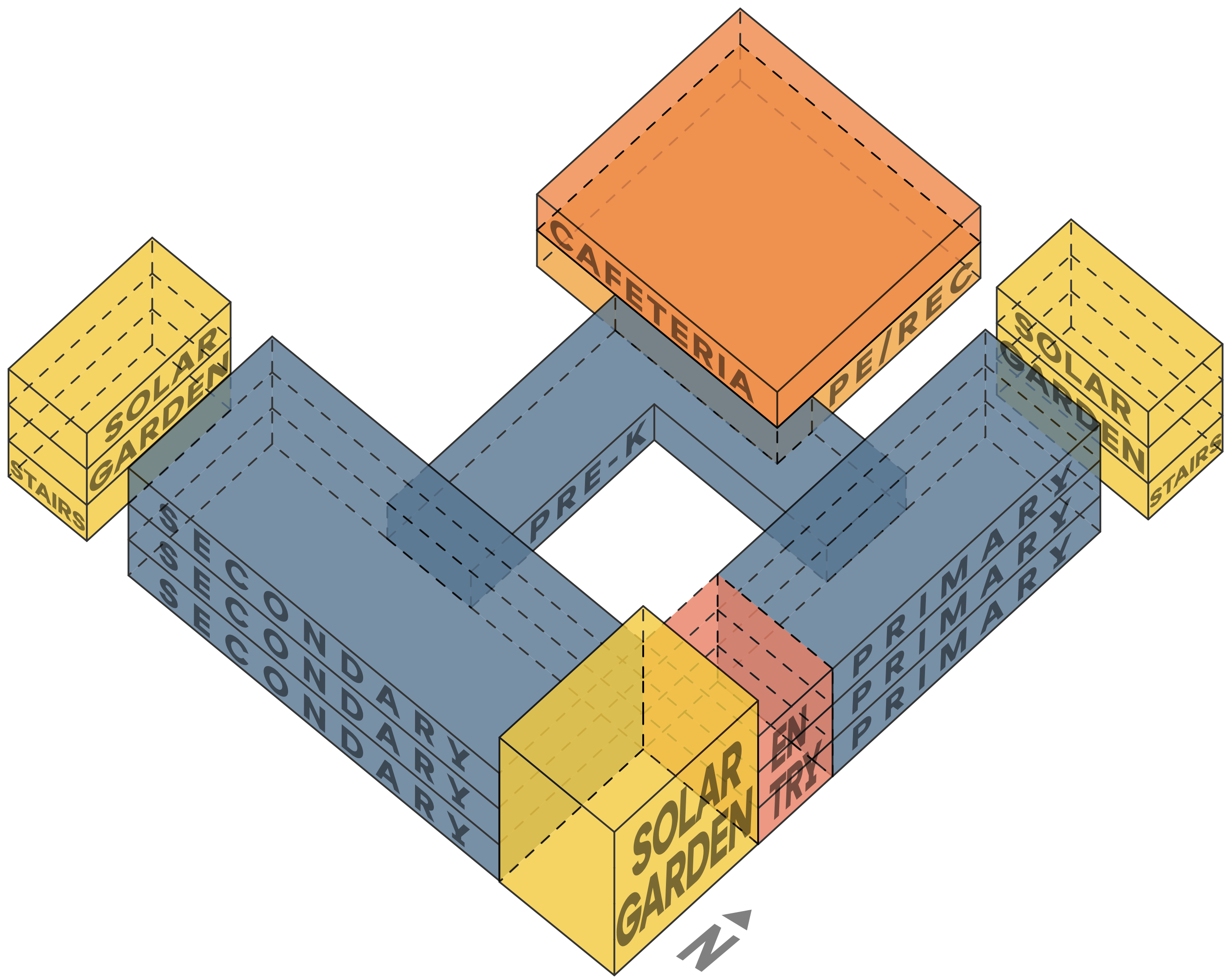
1. Guhl, Amy. "5 Principles of Trauma-Informed Design." Web log. Neumann Monson Architects (blog), December 15, 2022. https://neumannmonson.com/blog/principles-trauma-informed-design.
2. Mescheriakova, Maryna, Hanbin Guo, and Diana Hritsay. "Materials1." Kharkiv, Ukraine: Students of the Kharkiv Academy of Design and Arts, March 8, 2024.
3. Cannon Design, VS Furniture, and Bruce Mau Design. The third teacher: 79 ways you can use design to transform teaching & learning. New York, New York: Abrams, 2010.
4. Kazmierczak, Laura. "Nature's Cure: How Biophilic Design Can Enhance Healing." Medical Construction and Design, December 4, 2018. https://mcdmag.com/2018/04/natures-cure-how-biophilic-design-can-enhance-healing/.

HOW CAN BIOPHILIC AND NET-ZERO DESIGN PROVIDE HOPE AND HEALING FOR WAR-TORN COMMUNITIES?

WHAT IF WE USE MODULAR DESIGN TO LOWER OUR CARBON FOOTPRINT IN POST-WAR ADAPTIVE REUSE PROJECTS?

HOW CAN WE MAKE LEARNING ABOUT SUSTAINABILITY MORE ACCESSIBLE FOR STUDENTS BY USING ARCHITECTURE AS A THIRD TEACHER?

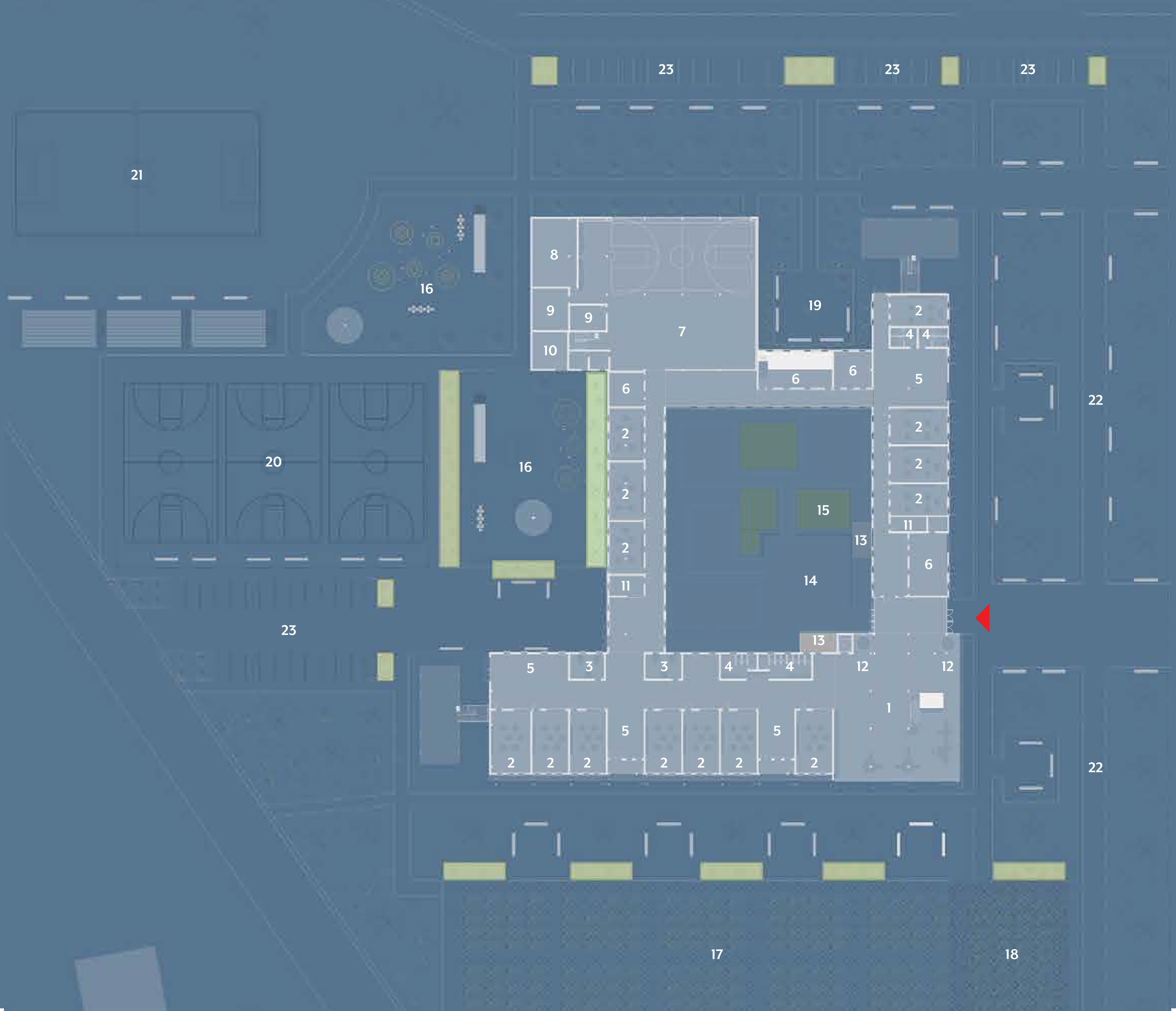

Modular Prototype School System
Induction Solar Heating w/ Data Farm Server
Geothermal Heat Pump
Integrated PVs
Thermal Mass
Living Machine TM
Adaptive Envelope
Reuse and Retrofit Existing Building
Recycling Rubble In Floors And Thermal Mass
Demonstration of Passive and Active Systems in Courtyard
Excess Energy Redirected To Grid
No Exposed VOCs or Red List Materials
Supporting Economy by Using Local Materials
Common Spaces Open For Public Use
Daylighting and Fresh Air Ventilation
Residential Walk Score of 99
Energy Recovery Ventilation
Water Conserving Features
Biophilic Principles Implemented
Students Learning From The Building
High Insulation (R-69 Roof, R-60 Walls, R-30 Radiant Floors)



PROGRAM

TOTAL SQUARE FOOTAGE - 104,300

While keeping the traditional Ukrainian school system in mind, we decided to add solar gardens to introduce learning about sustainability into the school system.



SITE + FLOOR 0

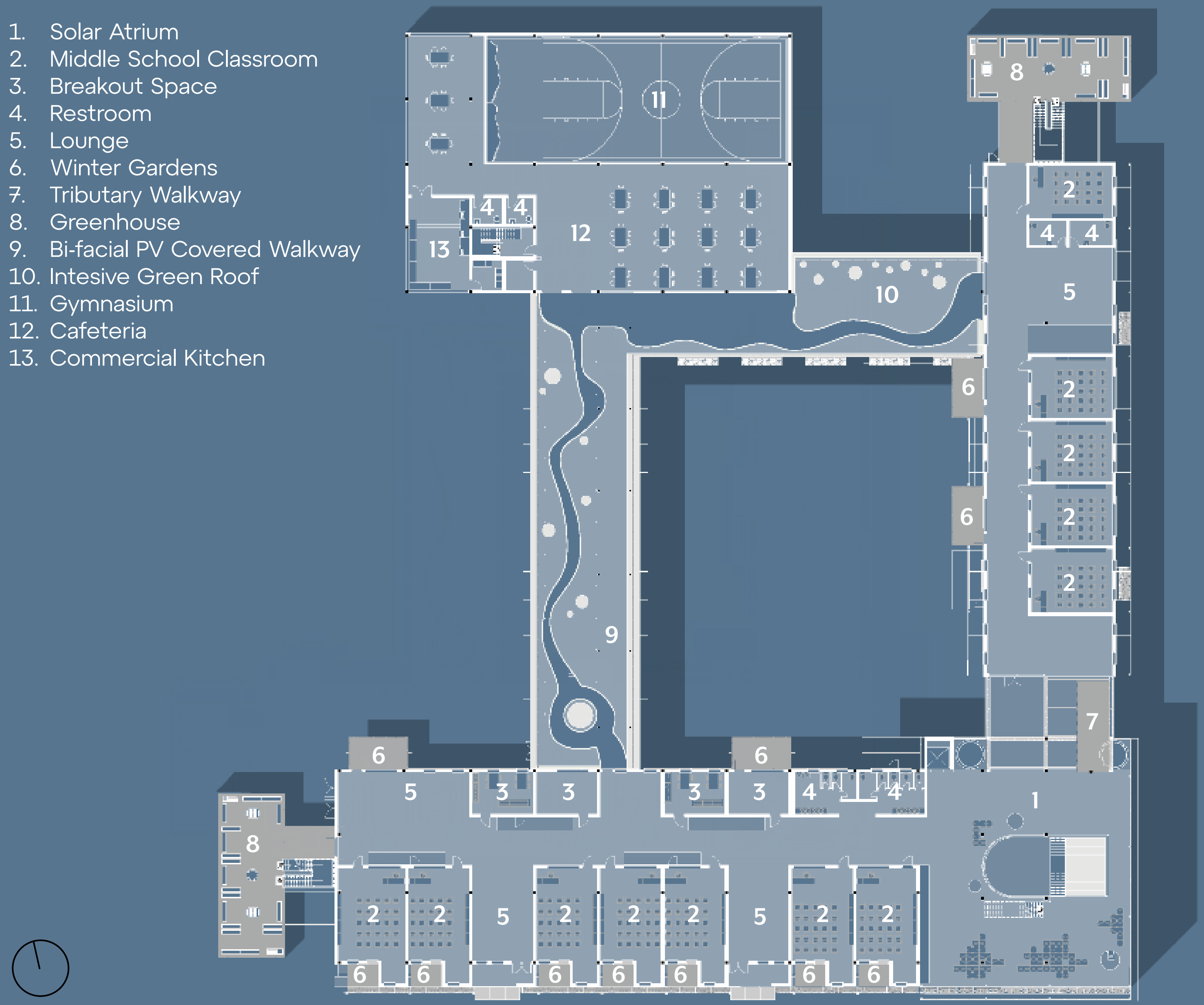
1:500

1. Solar Atrium
2. Elementary Classroom
3. Breakout Space
4. Restroom
5. Lounge
6. Admin
7. Gymnasium
8. Weight Room
9. Locker Room
10. Mechanical Room
11. Custodian Closet
12. Living Machine Basins
13. Outdoor Classroom
14. Inner Courtyard
15. Sensory Garden
16. Playground
17. Community Garden
18. Effluent Wetland
19. Northern Garden
20. Basketball Courts
21. Football Stadium
22. Promenade
23. Parking

FLOOR 1

1:200

1. Solar Atrium
2. Middle School Classroom
3. Breakout Space
4. Restroom
5. Lounge
6. Winter Gardens
7. Tributary Walkway
8. Greenhouse
9. Bi-facial PV Covered Walkway
10. Intesive Green Roof
11. Gymnasium
12. Cafeteria
13. Commercial Kitchen



FLOOR 2

1:200

1. Solar Atrium
2. Vocational Classroom
3. Breakout Space
4. Restroom
5. Lounge
6. Winter Gardens

Solar Garden Library Oculus

The top floor of the solar garden library features a quiet space where you can relax between classes or grab a book.

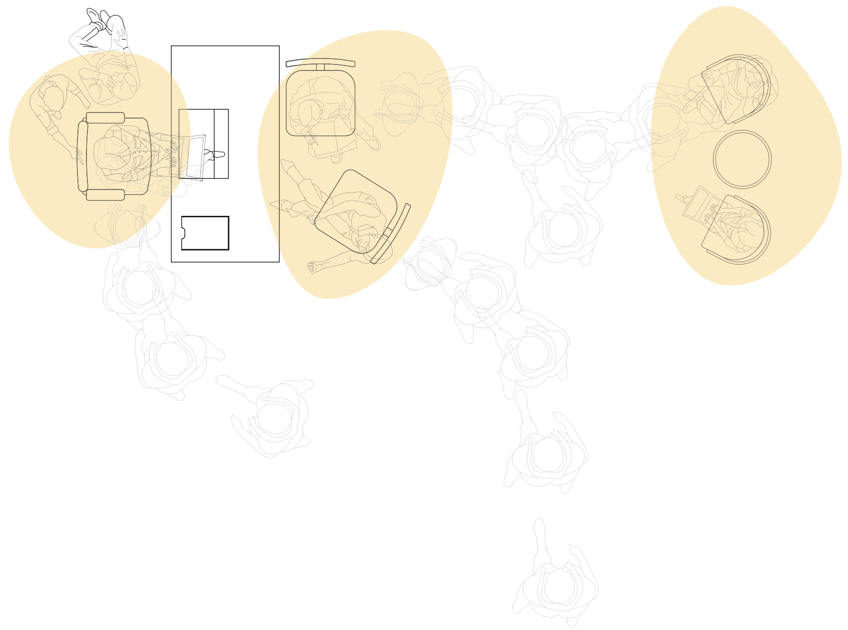
Old and New Bridge

The bridge showcases the school's old structure while connecting to the new mass timber structure.

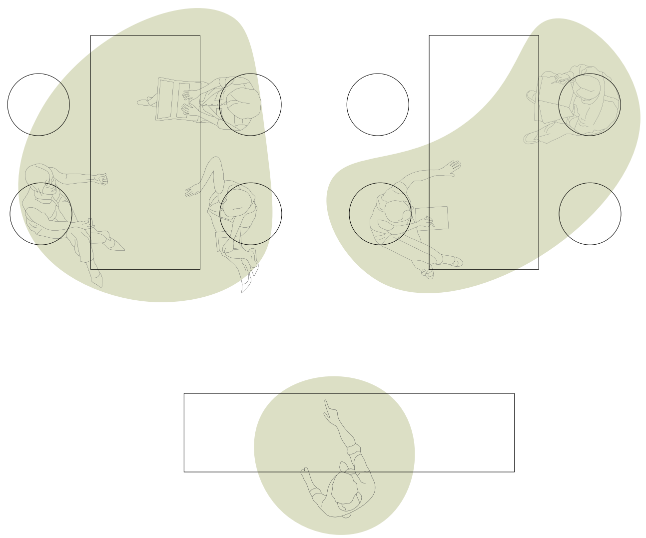
Living Machine® Interior Marsh

The fourth and sixth steps of the living machine are shown on the ground floor to help spark curiosity among students and visitors.

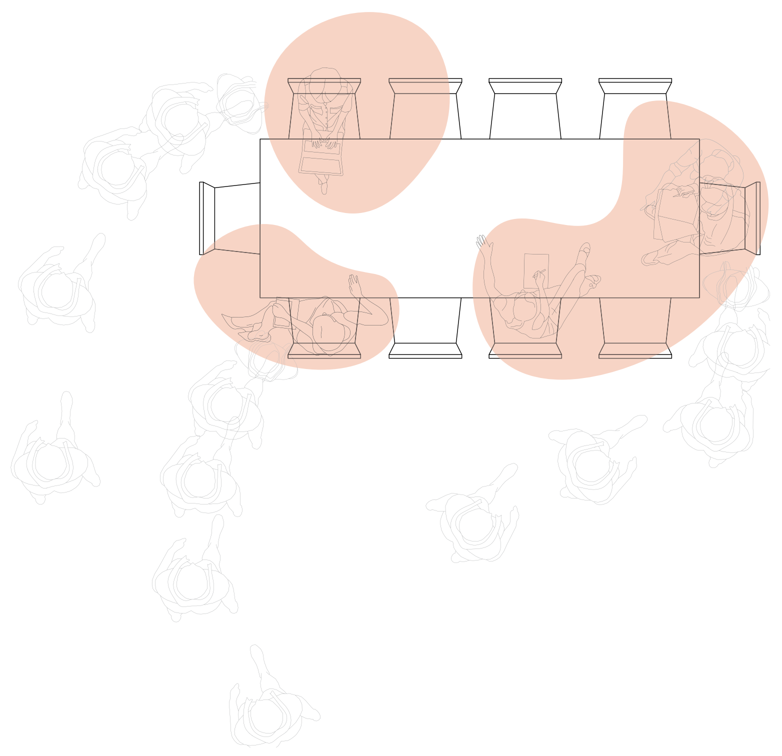
TEACHER OFFICE

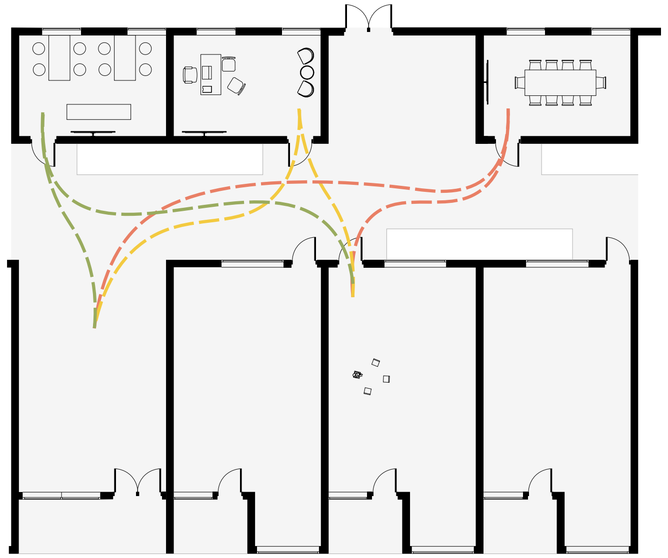


LAB SPACE

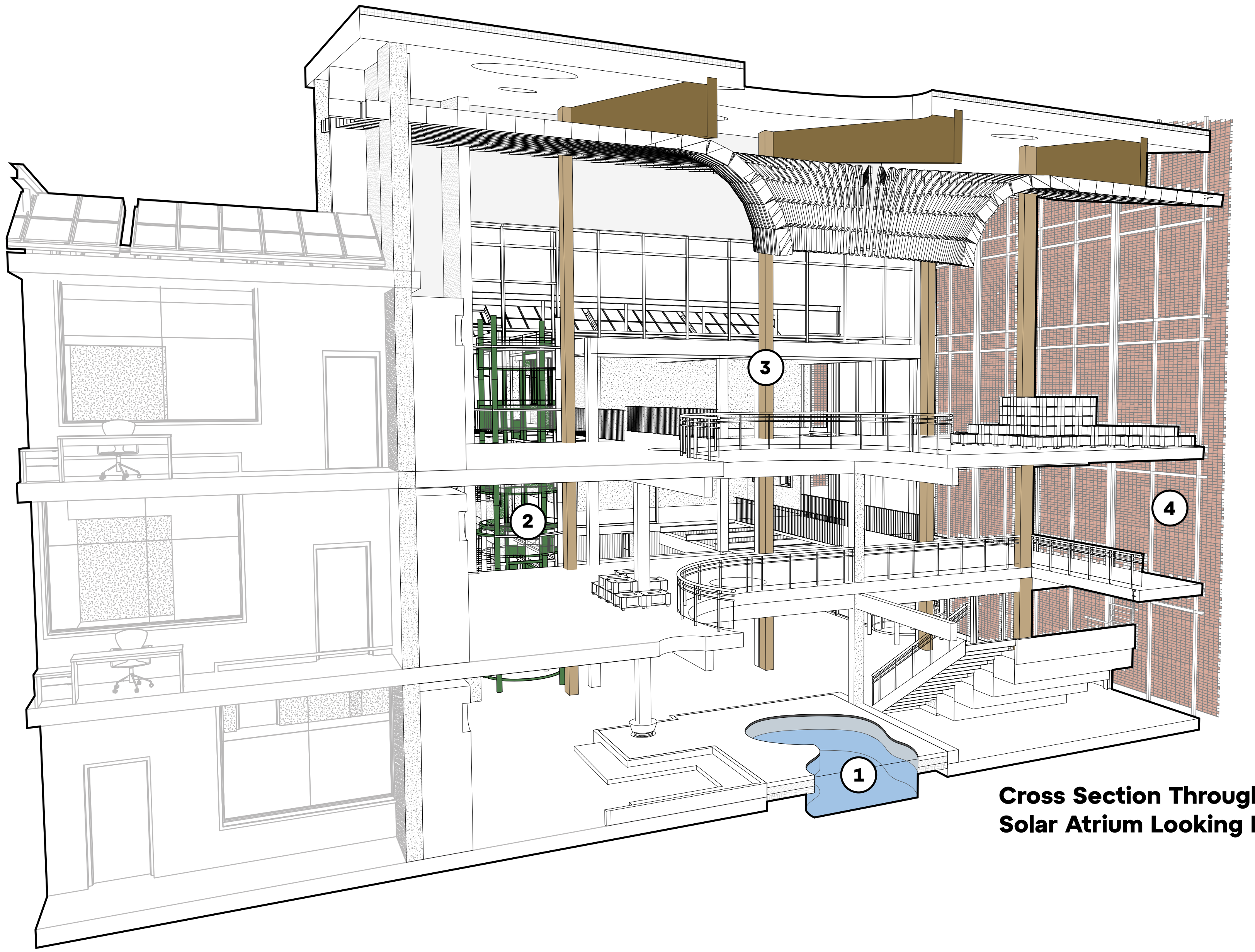


STUDY ROOM





The new south wing is designed to create flexible space between classrooms, offices, study rooms, and labs.



Cross Section Through Solar Atrium Looking North

① Living Machine TM Effluent Wetland
typical wetland species remove the remaining nitrogen through root systems and convert them to harmless nitrogen gas.

② Living Machine TM Tanks
"aerated and supplied with bacteria, plants, algae, snails, insects, and fish. In these tanks ammonia and organic nitrogen are converted to nitrates. Each one is capable of handling 75% of the maximum daily flow."

③ Mass Timber Supporting Columns And Beams
using mass timber to rebuild the new wind and solar atrium can reduce the embodied energy by 20-50% compared to concrete construction.

④ Terracotta Shading Screen
using terracotta in beneficial for our building due to its mass production, long life cycle, low maintence and insulative properties.

Mechanical Systems

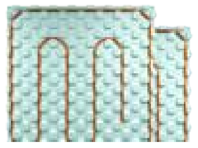
Product Information

Product: Ecodan QAHV Monobloc Air Source Heat Pump
Location: Gymnasium and cafeteria
Function: Heating and cooling for gym and cafeteria
Features:

- Operational limit -25°C
- Utilises CO_2 refrigerant with a GWP of 1
- Uses a spiral gas cooler to enhance energy efficiency

Product: Water Furnace Envision NDW Geothermal Heat Pump
Location: Mechanical room in gymnasium
Function: Regulates temperature of R-410A liquid feeding into radiant floor slabs
Features:

- Efficiency: Up to 3.5 COP; Up to 22.0 EER
- Size: 15 ton dual compressor
- 60% energy cost reduction compared to conventional systems



Product: Isolofoam Isorad V2 Hydronic Radiant Concrete Slab Heating
Location: Whole building floor plates in climate regulated zones
Function: Regulates temperature of building through hydronic radiant concrete slabs
Features:

- Enables separation of heating zones through multidirectional tube retention
- Reduces heat loss through EPS thermal barrier
- Greenguard Gold-certified product

Product: SunEarth Indirect Loop Glycol Solar Hot Water System
Location: Rooftops of wings, interspersed with solar panels
Function: Provide hot water for building use
Features:

- Impervious to freezing
- High efficiency relative to other types of solar water heating
- Used in combination with SunEarthCASCADE 2 Hot Water Station

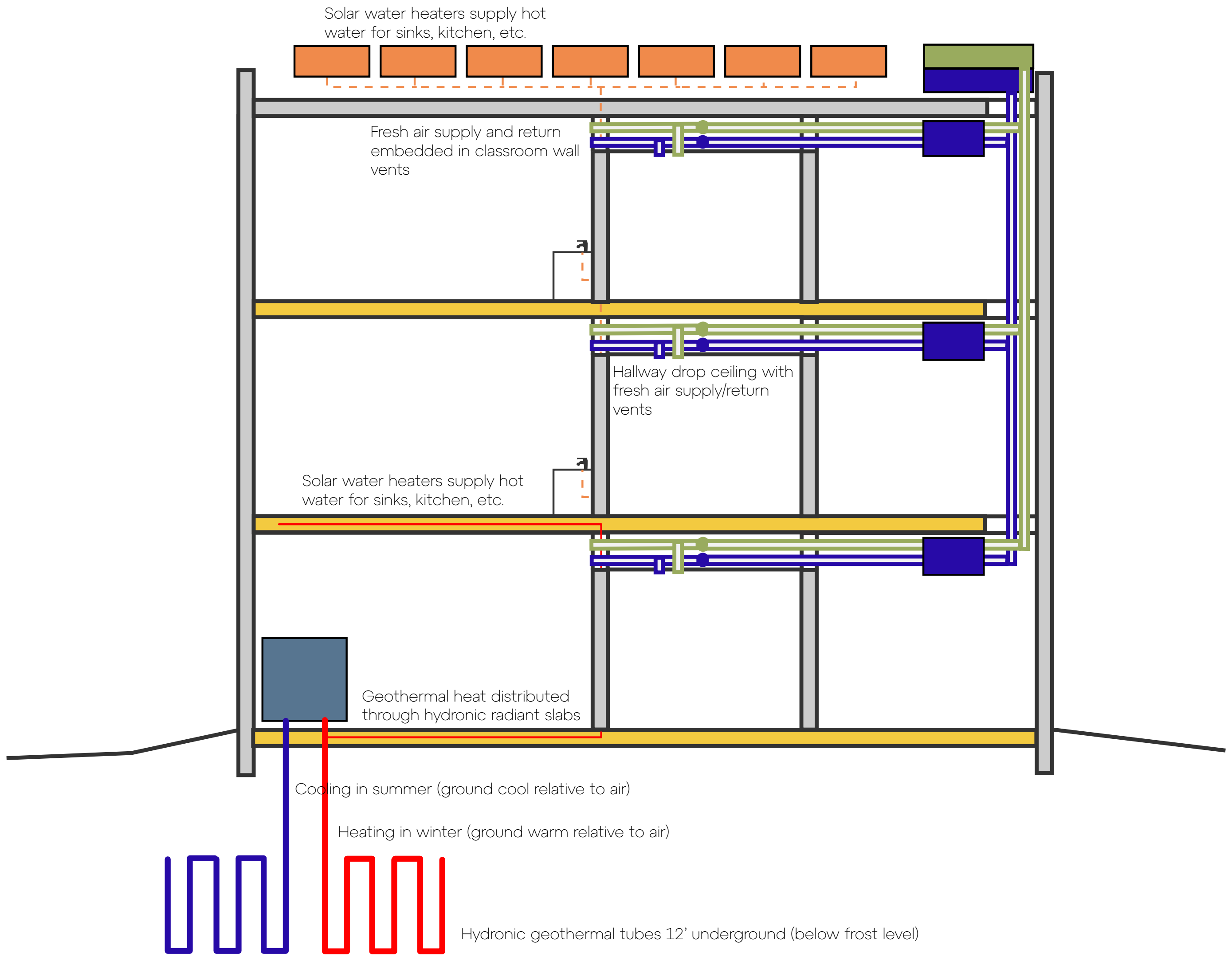
Product: SolerPalau HRSB and HRSD Fresh air Supply and Return Roof Vents
Location: Rooftops of classroom wings and library
Function: Fresh air supply and exhaust to classroom wings and library
Features:

- Rated to over 56,000 CFM
- Static pressure capability up to 3/4"

Product: FieldControls Model FC200ERV Energy Recovery Ventilator
Location: One per floor per classroom wing, ceiling-mounted
Function: Fresh air supply and exhaust to classroom wings and library, heat recovery from outgoing hot air to incoming cold air (winter)
Features:

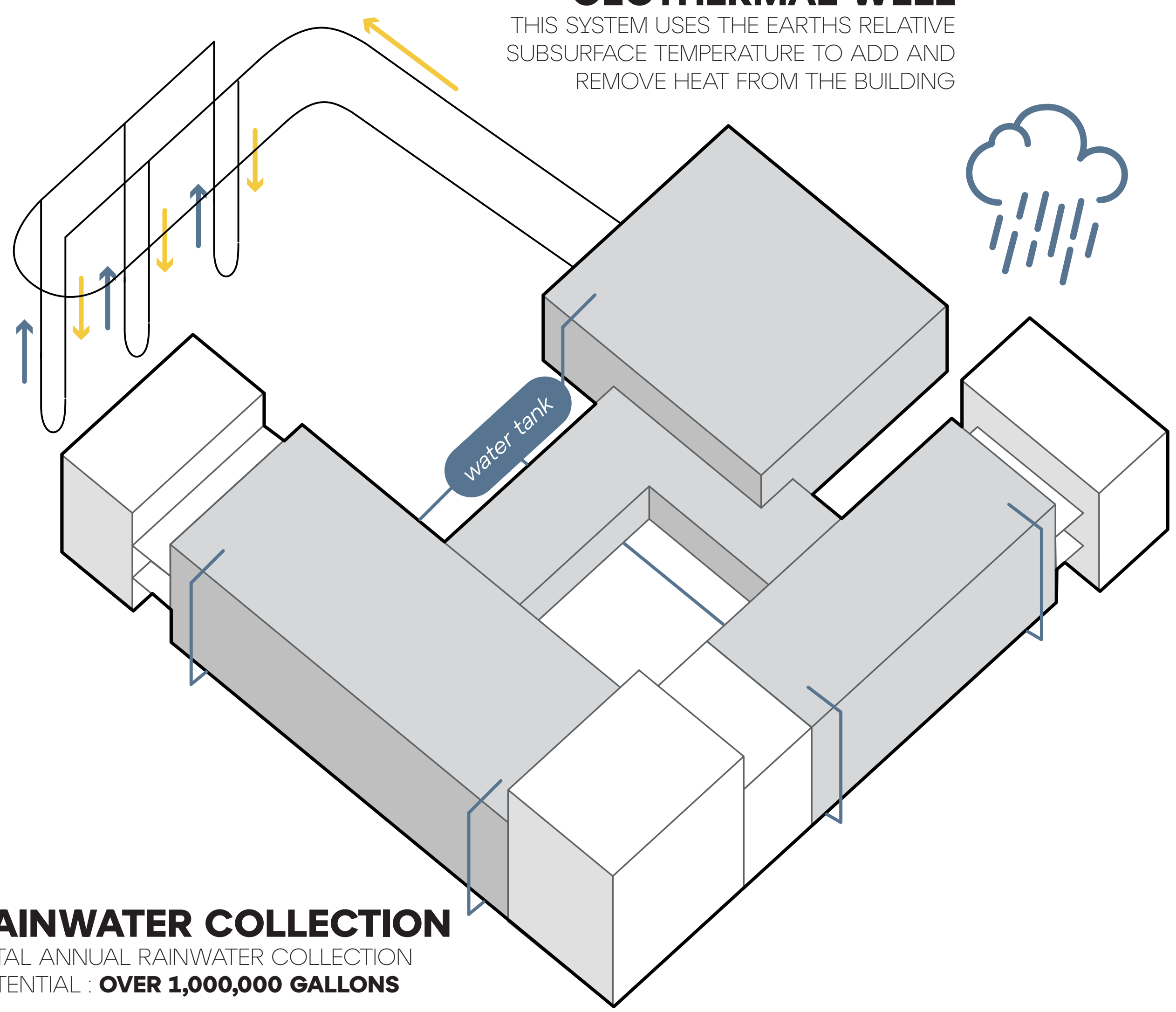
- 81% effectiveness at 32°F
- Humidity regulation via polymer membrane

Systems Section Through Classroom Wing



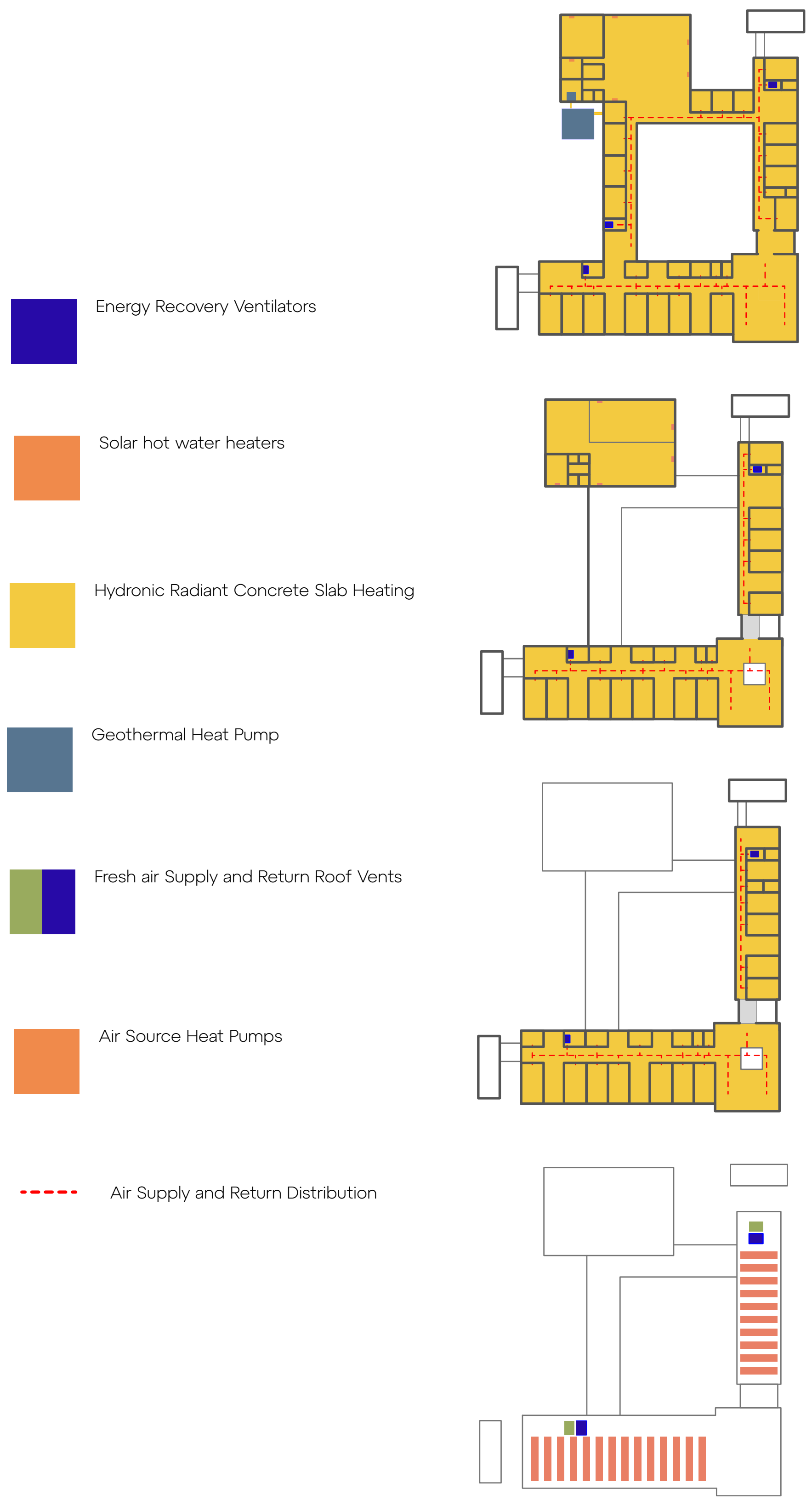
GEOTHERMAL WELL

THIS SYSTEM USES THE EARTHS RELATIVE SUBSURFACE TEMPERATURE TO ADD AND REMOVE HEAT FROM THE BUILDING

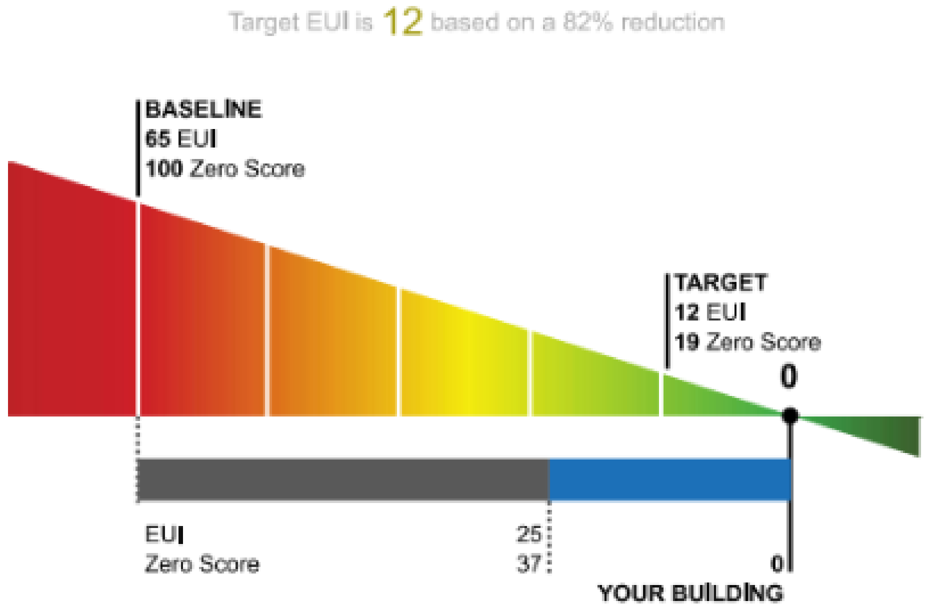


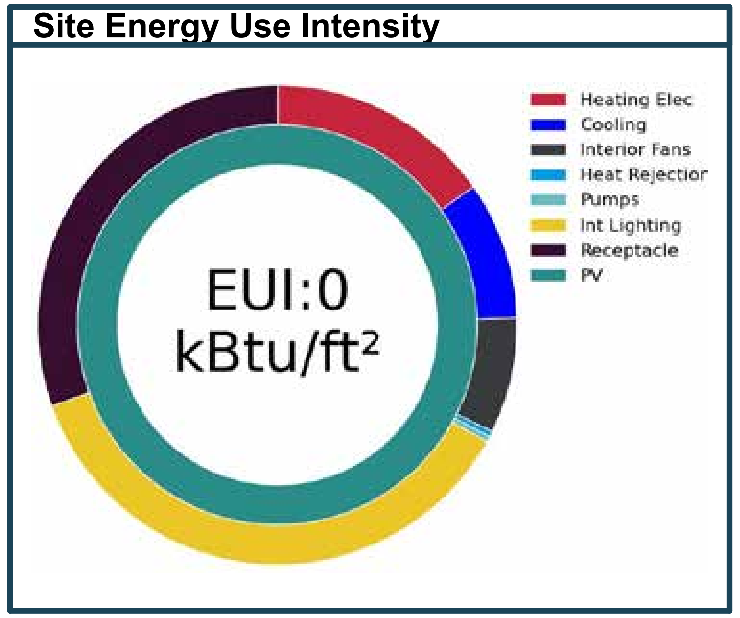
RAINWATER COLLECTION

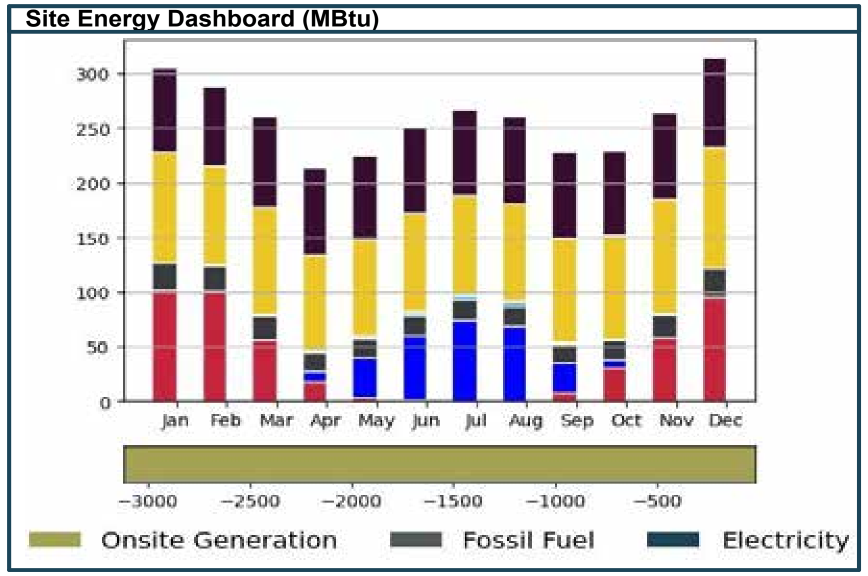
TOTAL ANNUAL RAINWATER COLLECTION POTENTIAL : **OVER 1,000,000 GALLONS**



EUI Target vs EUI Reached

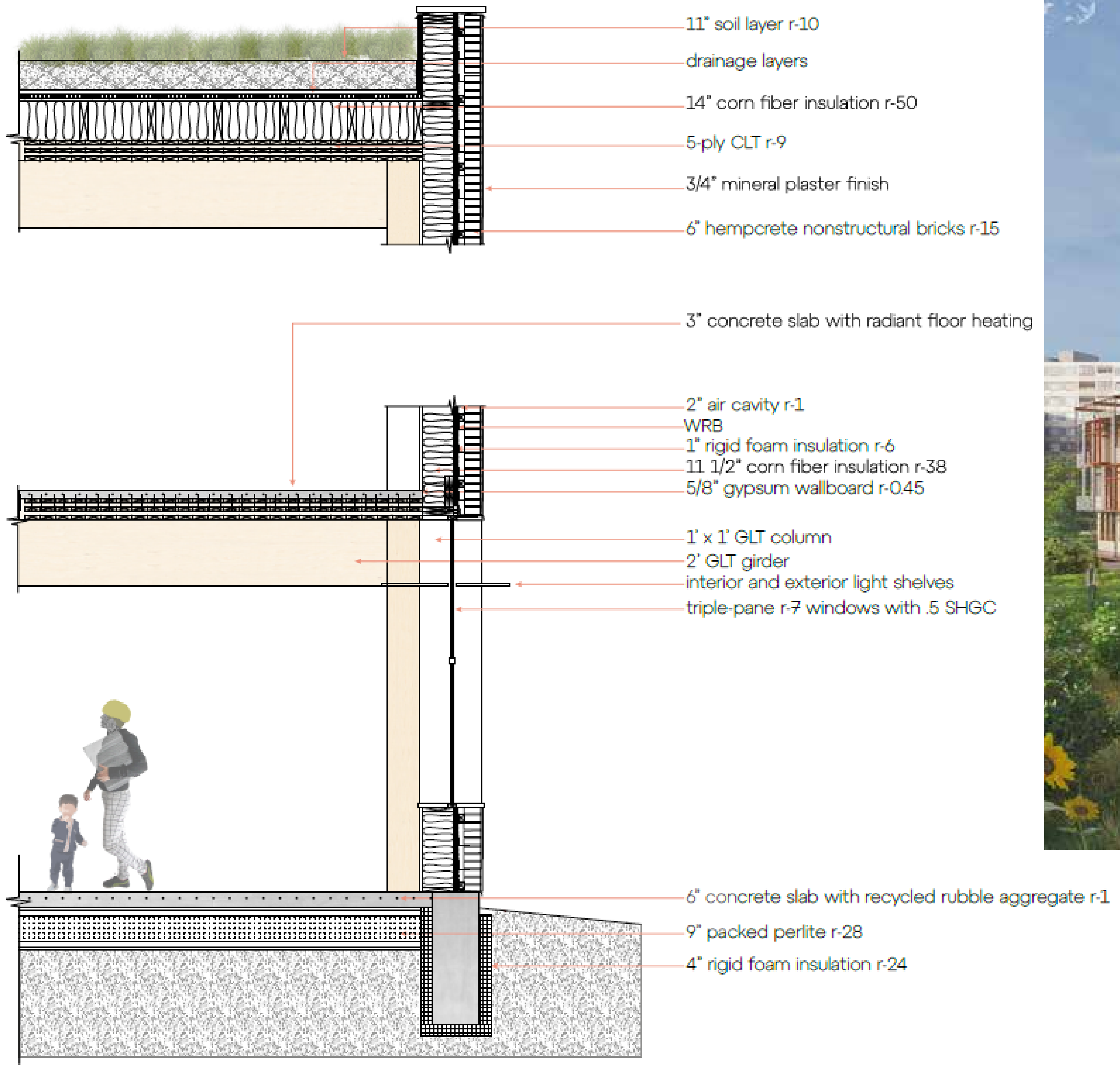






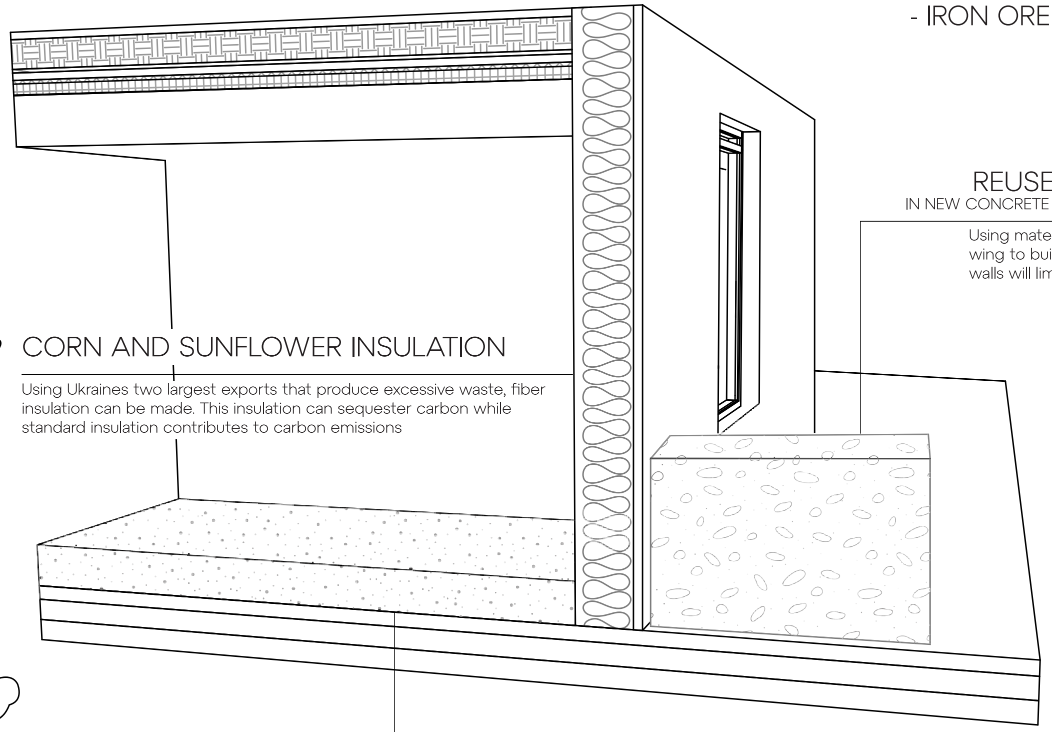
Annual Energy Consumption (kBtu/ft²/year) & CO2 KgCO2/ft²/yr

Energy End Use	Site Energy	Source Energy	CO2 Emissions
Heating Fossil Fuel	0.0	0.0	0.0
Heating Electricity	4.1	12.6	0.0
Space Cooling	2.5	7.6	0.0
Fans Interior	2.1	6.4	0.0
Heat Rejection	0.1	0.3	0.0
Pumps	0.1	0.4	0.0
DHW Fossil Fuel	0.0	0.0	0.0
DHW Electricity	0.0	0.0	0.0
Interior Lighting	9.8	30.2	0.0
Exterior Lighting	0.0	0.0	0.0
Receptacle	8.2	25.1	0.0
Data Center	0.0	0.0	0.0
Cooking Fossil Fuel	0.0	0.0	0.0
Cooking Electricity	0.0	0.0	0.0
Elevators & Escalators	0.0	0.0	0.0
Refrigeration	0.0	0.0	0.0
Process	0.0	0.0	0.0
TOTAL (ex renewables)	26	82	0


11" soil layer r-10
drainage layers
14" corn fiber insulation r-50
5-ply CLT r-9
3/4" mineral plaster finish
6" hempcrete nonstructural bricks r-15
3" concrete slab with radiant floor heating
2" air cavity r-1
WRB
1" rigid foam insulation r-6
11 1/2" corn fiber insulation r-38
5/8" gypsum wallboard r-0.45
1' x 1' GLT column
2' GLT girder
interior and exterior light shelves
triple-pane r-7 windows with .5 SHGC
6" concrete slab with recycled rubble aggregate r-1
9" packed perlite r-28
4" rigid foam insulation r-24

Cultural Material Application

UKRAINE'S TOP EXPORTS:
- SUNFLOWER PRODUCTS
- CORN
- IRON ORE



REUSE OF RUBBLE
IN NEW CONCRETE SLABS + LANDSCAPE

Using materials from the impacted southern wing to build landscaping and and trombe walls will limit the need for new materials

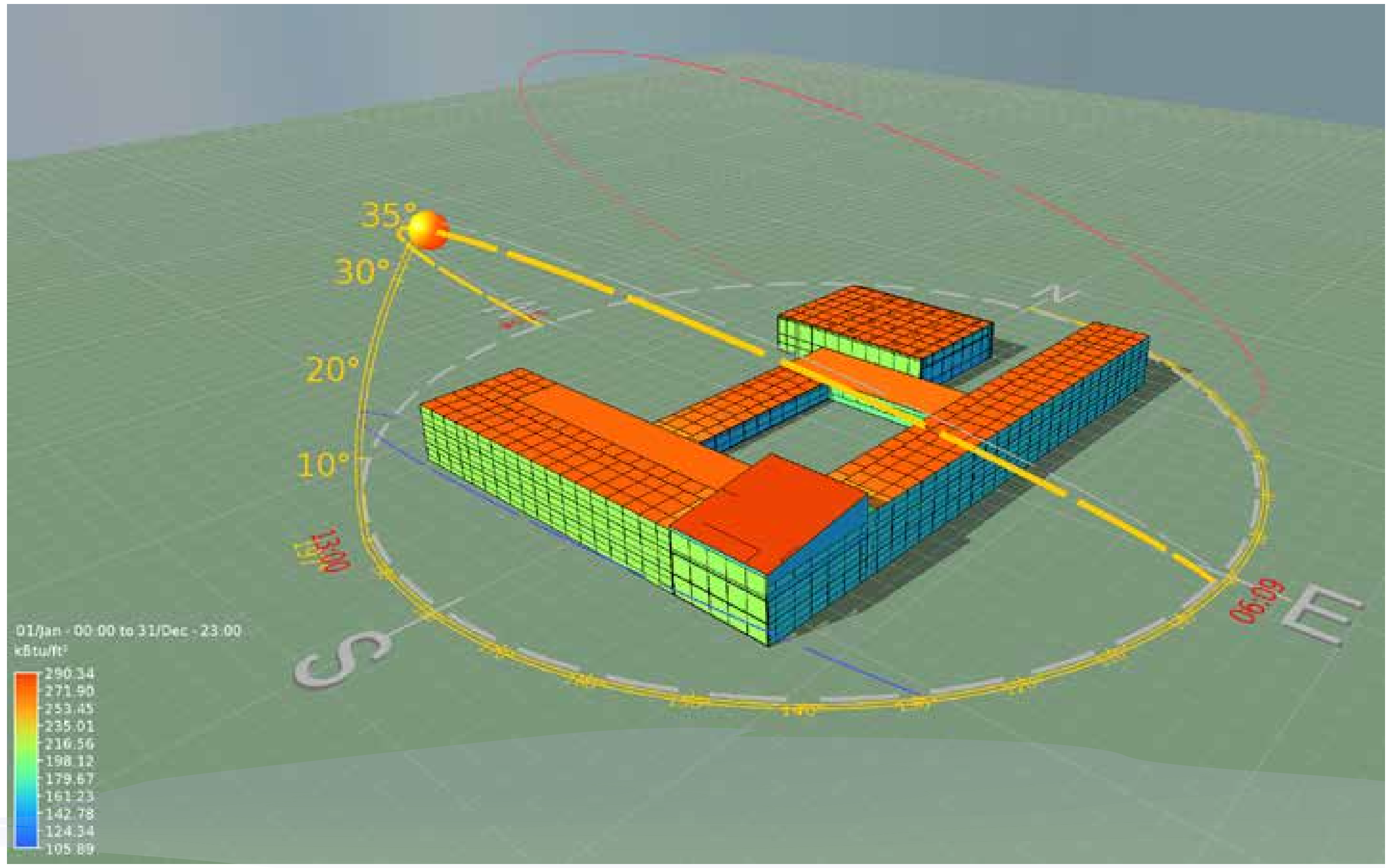
CORN AND SUNFLOWER INSULATION

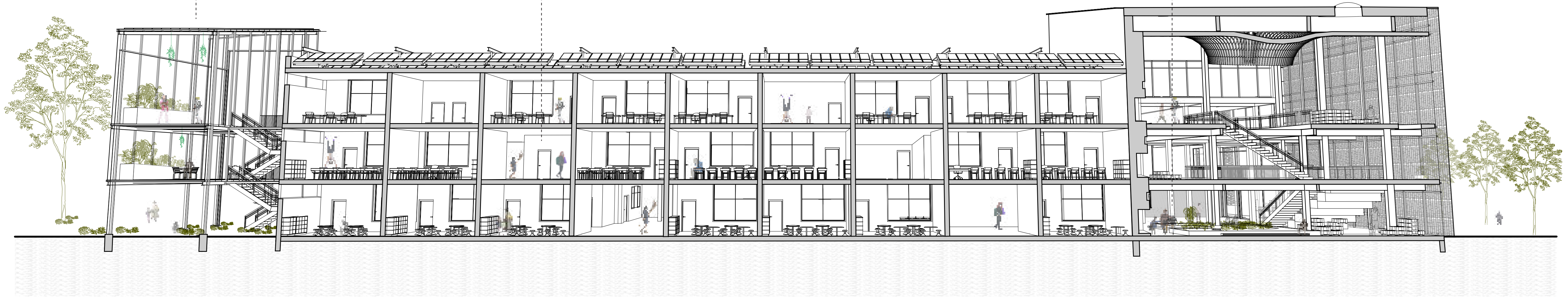
Using Ukraines two largest exports that produce excessive waste, fiber insulation can be made. This insulation can sequester carbon while standard insulation contributes to carbon emissions

FLY ASH CONCRETE
IN NEW CONSTRUCTION

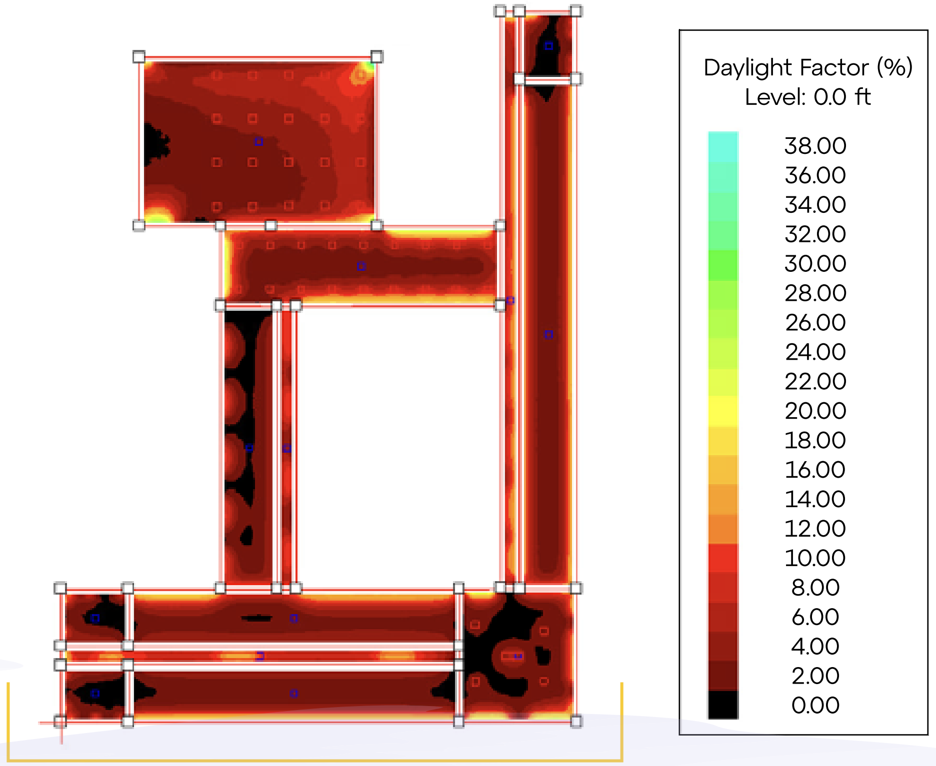
Concrete is reponsible for 8% of CO_2 emissions. The use local ash can increase constructability and strength of concrete, and partially replaces cement use

The new double loaded wing allows for light to enter through skylights in the hallways lighting the classrooms, offices and labs with natural daylighting. The new wing also supports a large amount of photovoltaic panels that get extensive sun exposure.

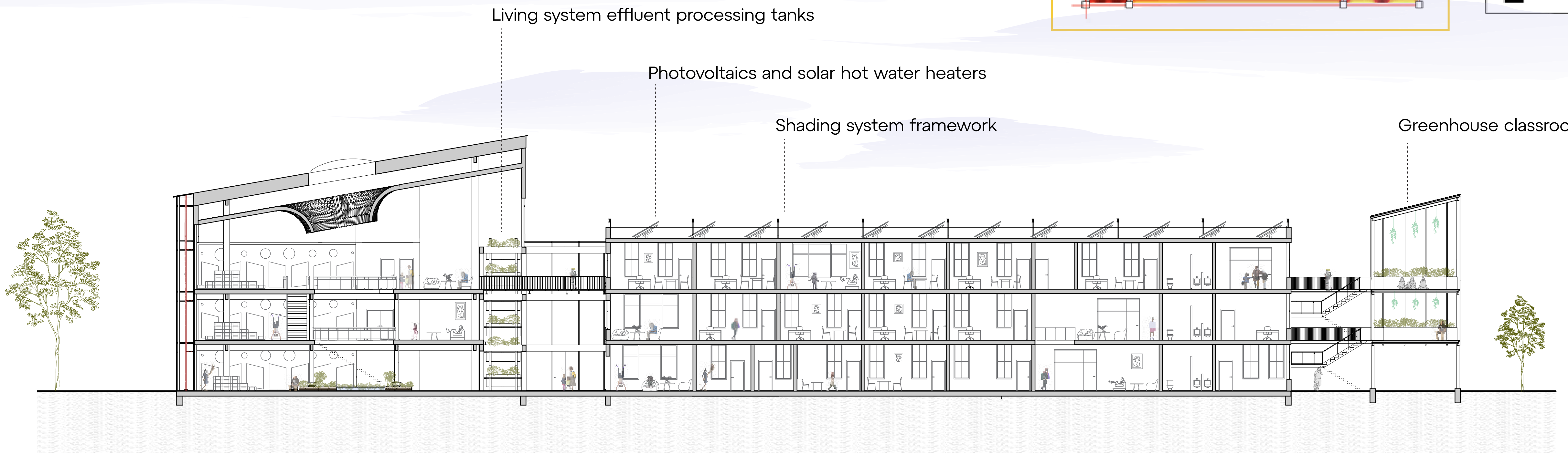


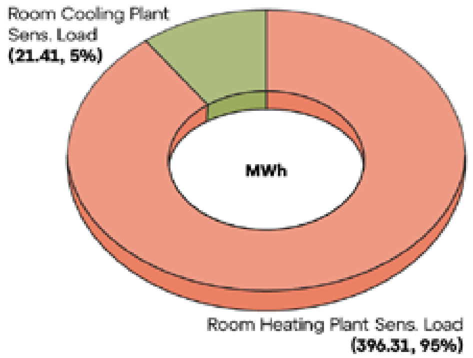


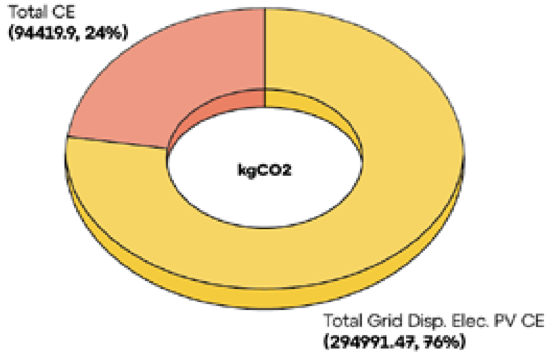
Most of the educational spaces are receiving 2-5% DF and 90% of the areas have a DA 300 lux

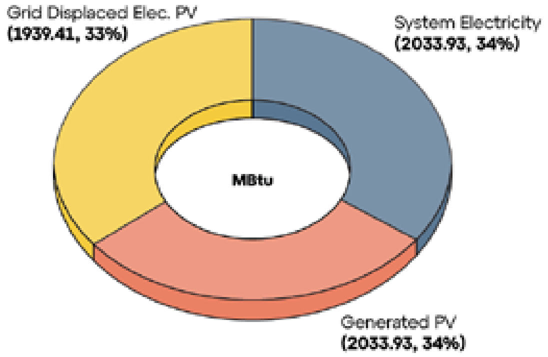


The use of a large opening in the solar garden allows for light to travel and disperse throughout open floor. In the class room wings there is sufficent ligth during the day limiting the need for electic lighting cutting down on overall opperational costs.



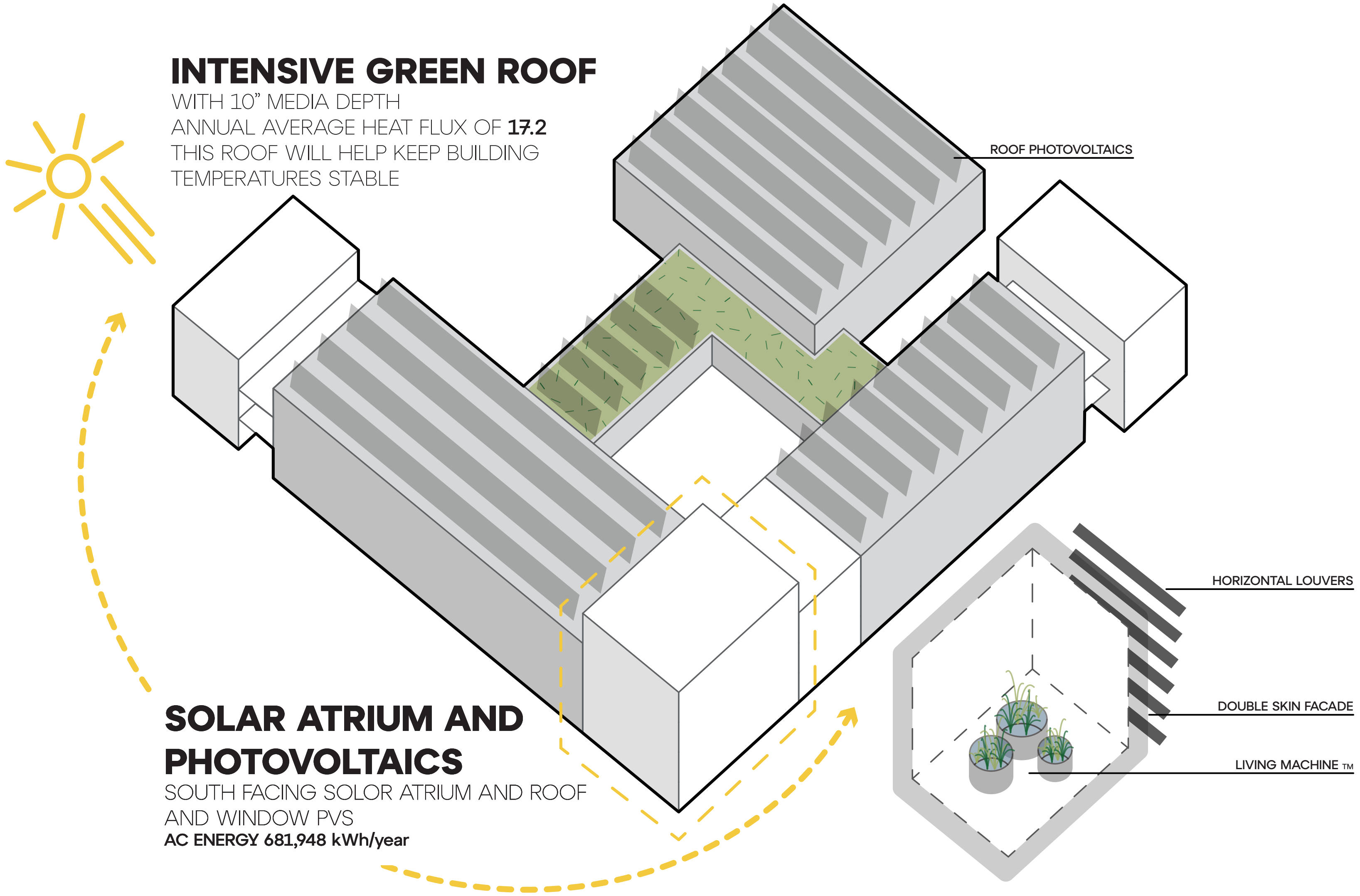




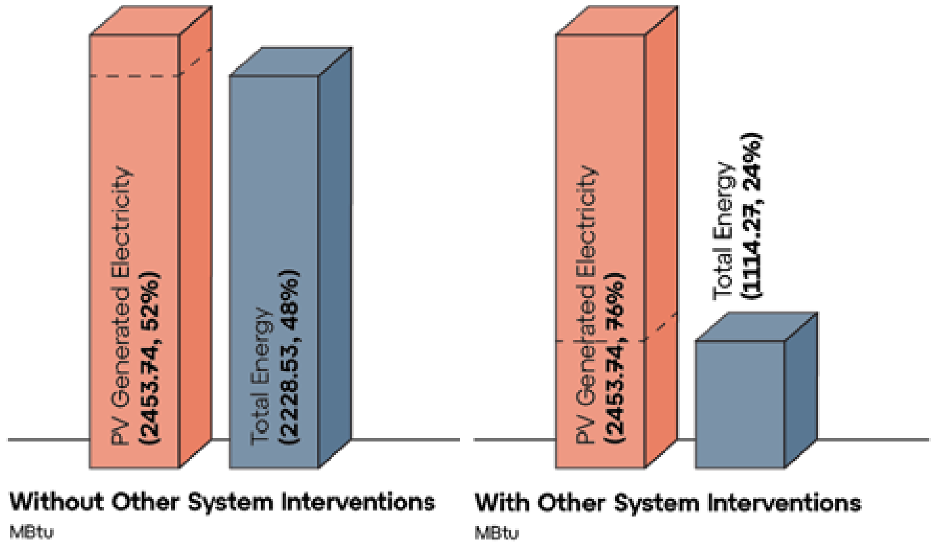


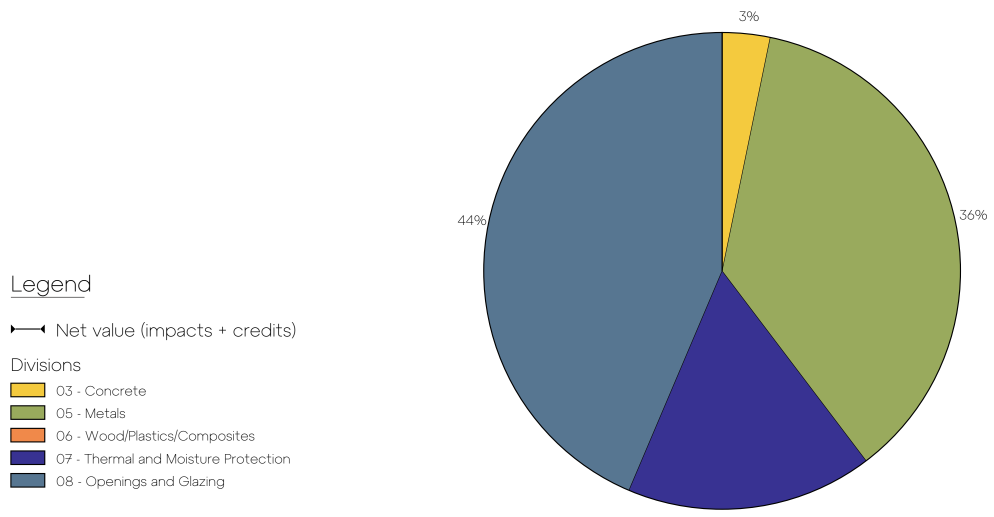
Annual Fuel Costs and Peak Demands

Fuels	Cost (£)	Peak Day	Peak Time	Peak Demand
Electricity	84,506.00	18-Jan	9:00	457.0 kW
Fossil Fuel	0.00	01-Jan	0:00	0.0 kBtu/h
Total	84,506.00	01-Jan	0:00	



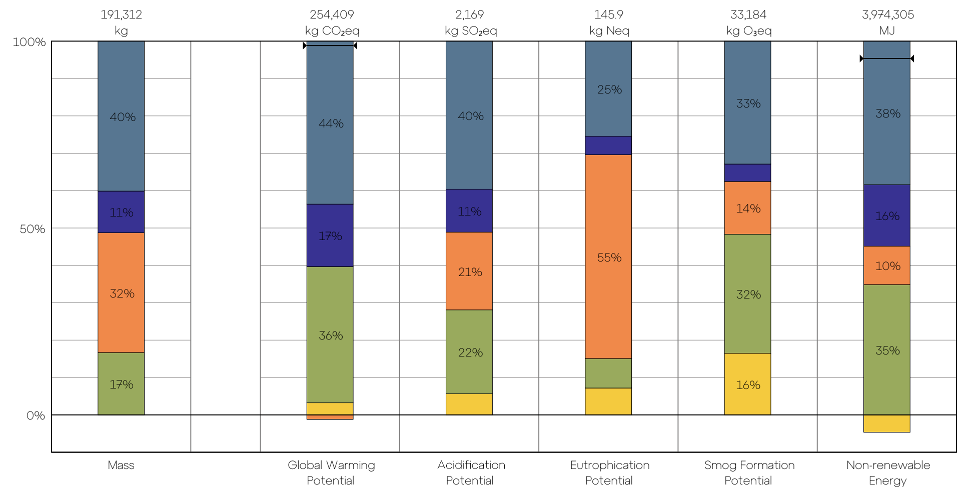
Integrating photovoltaic systems (PVs) into a building's design offers numerous benefits, especially with innovative technologies like bifacial panels for covered outdoor walkways and one-axis tracking systems on roofs.

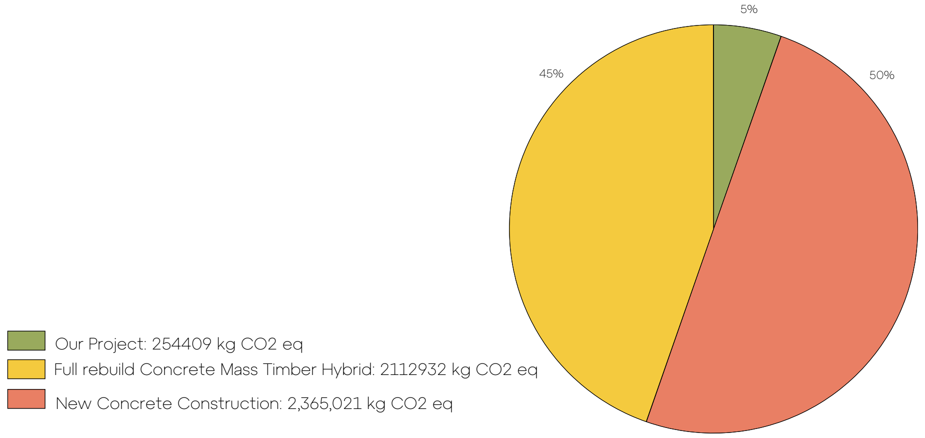




Global Warming Potential

Our Project: Tally LCA Results



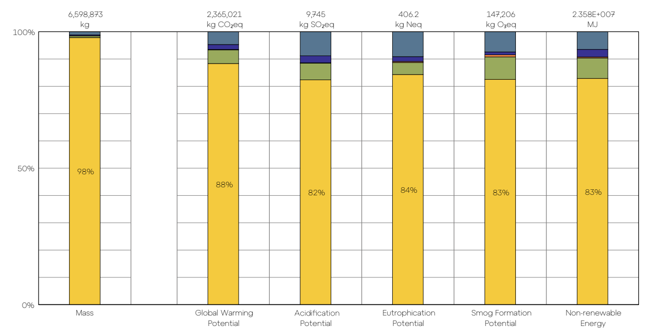


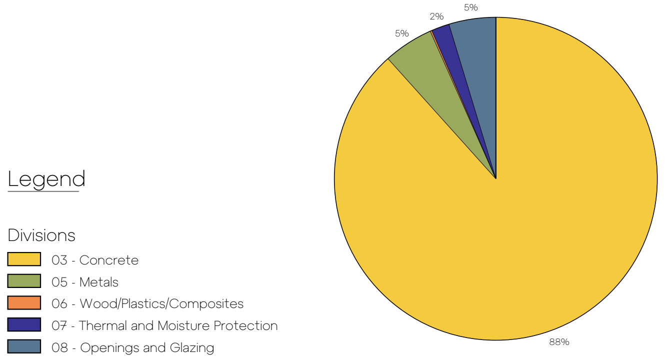
Global Warming Potential: Comparing Three Scenarios

Environmental Impact Totals	Product Stage [A1-A3]	Construction Stage [A4]	Use Stage [B2-B5]	End of Life Stage [C2-C4]	Module D [D]
Global Warming (kg CO_2eq)	226,676	6,056	34,595	264,177	-280,116
Acidification (kg SO_2eq)	1,945	28.06	393.7	697.9	-895
Eutrophication (kg Neq)	63.65	2.285	30.92	73.60	-24.6
Smog Formation (kg O_3eq)	20,929	927.2	9,170	10,908	-8,751
Ozone Depletion (kg CFC-11eq)	0.002882	2.074E-010	0.001483	2.098E-008	0.001554
Primary Energy (MJ)	5,160,101	88,061	1,026,380	1,944,809	-3,218,944
Non-renewable Energy (MJ)	3,923,528	85,954	782,150	1,818,567	-2,820,737
Renewable Energy (MJ)	1,242,031	2,129	244,622	128,314	-399,535
Environmental Impacts / Area					
Global Warming (kg CO_2eq/m^2)	23.39	0.6249	3.570	27.26	-28.9
Acidification (kg SO_2eq/m^2)	0.2007	0.002896	0.04063	0.07203	-0.09241
Eutrophication (kg Neq/m^2)	0.006568	2.358E-004	0.003191	0.007596	-0.002538
Smog Formation (kg O_3eq/m^2)	2.160	0.09569	0.9464	1.126	-0.9031
Ozone Depletion (kg CFC-11eq/m^2)	2.975E-007	2.140E-014	1.530E-007	2.165E-012	1.603E-007
Primary Energy (MJ/m^2)	532.5	9.088	105.9	200.7	-332
Non-renewable Energy (MJ/m^2)	404.9	8.871	80.72	187.7	-291
Renewable Energy (MJ/m^2)	128.2	0.2198	25.25	13.24	-41.2

If we had designed this as a traditional building the concrete use would make up **87% of the global warming potential**, while with the **reuse of rubble** our LCA analysis the concrete only makes up **5% of global warming potential**

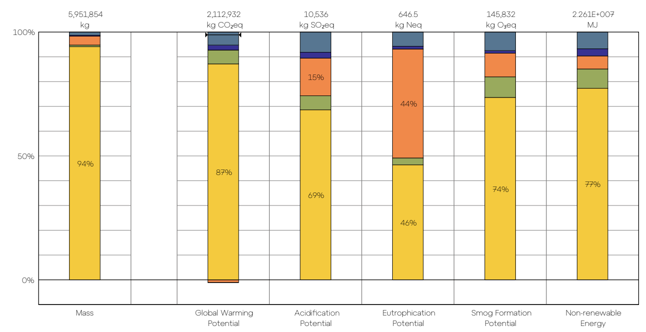
No Mass Timber: Tally LCA Results

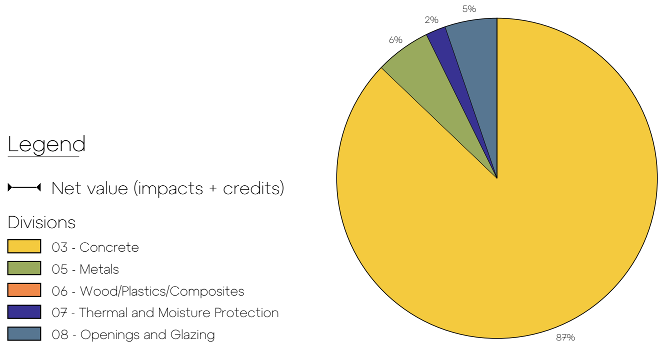




Global Warming Potential

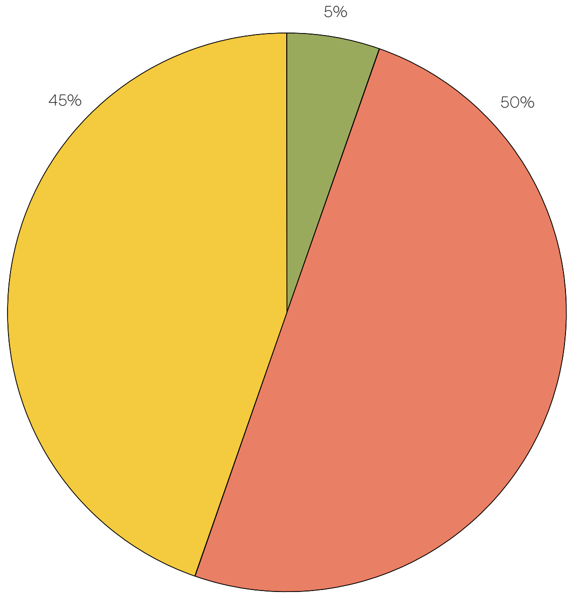
No Salvaged Concrete: Tally LCA Results





Global Warming Potential

Our Project: 254409 kg CO2 eq
Full rebuild Concrete Mass Timber Hybrid: 2112932 kg CO2 eq
New Concrete Construction: 2,365,021 kg CO2 eq

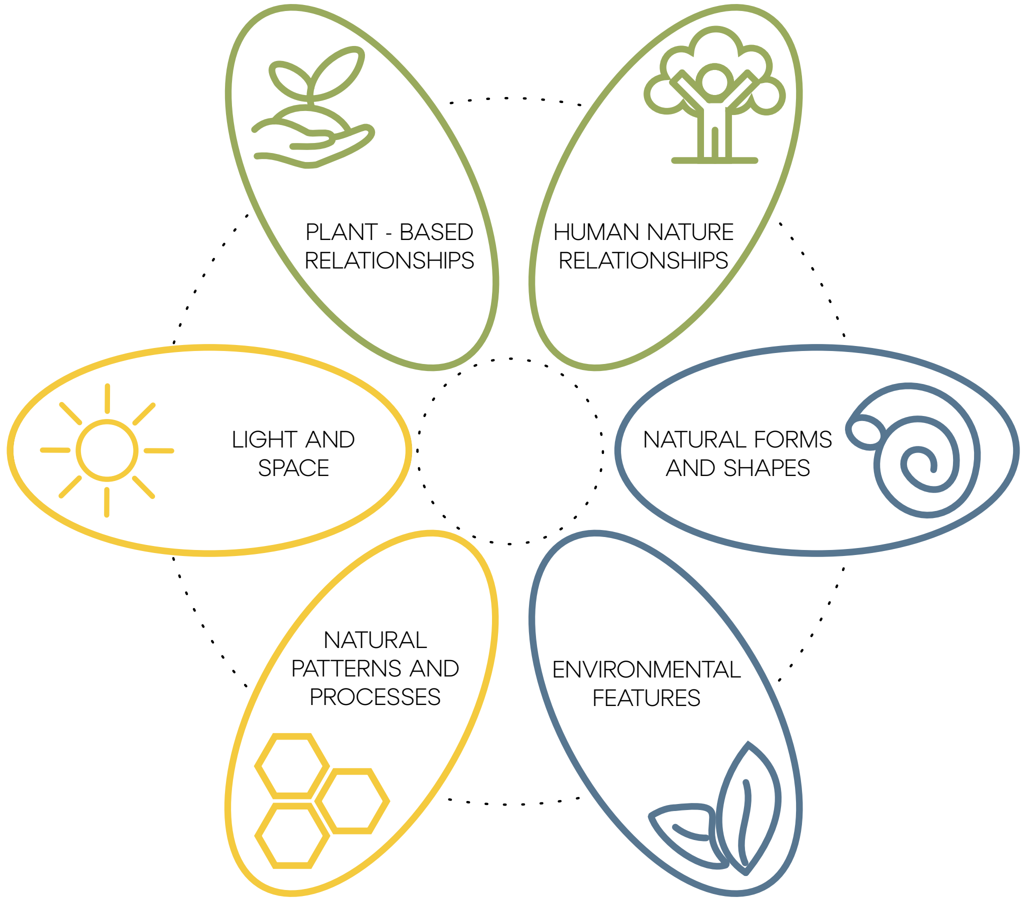


Global Warming Potential: Comparing Three Scenarios

FIVE IMPLIMENTED PRINCIPLES OF

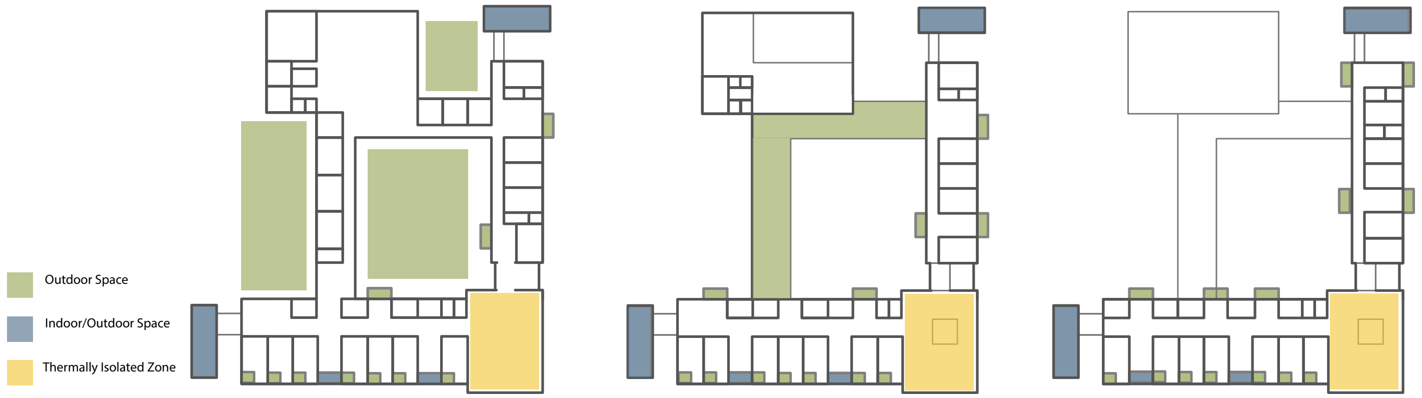
TRAUMA-INFORMED DESIGN

+

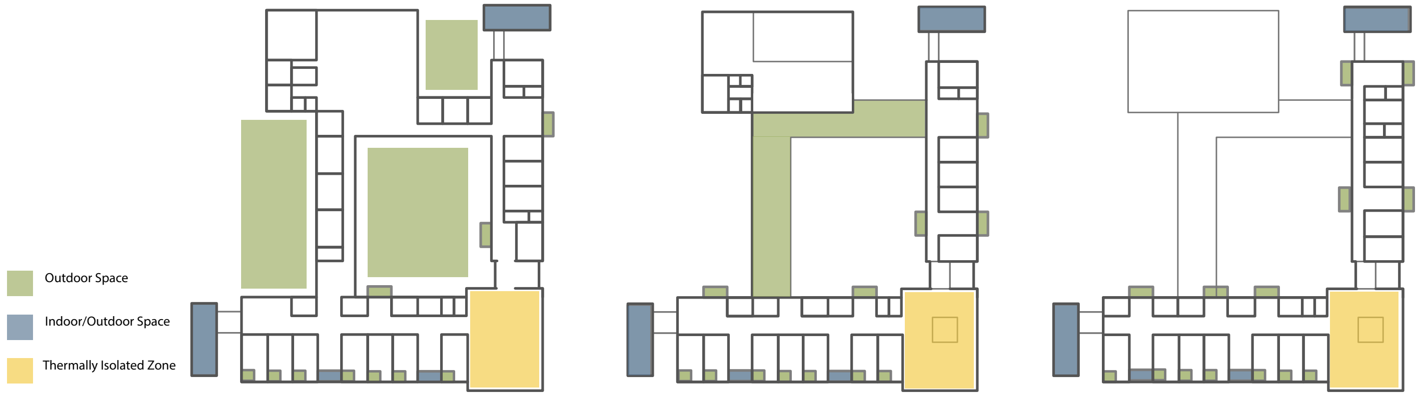


SIX IMPLIMENTED PRINCIPLES OF

BIOPHILIC DESIGN



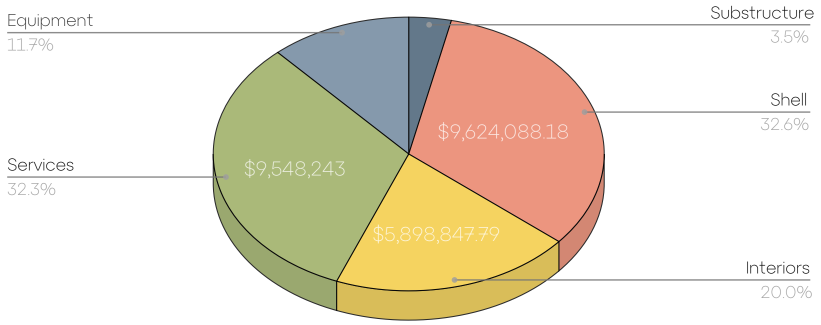
Providing green space for students allows for connection to the outdoor and with peers through natural play.



Green space is essential to health, we have implimented a living system into our solar garden allowing for quick access to greenery.

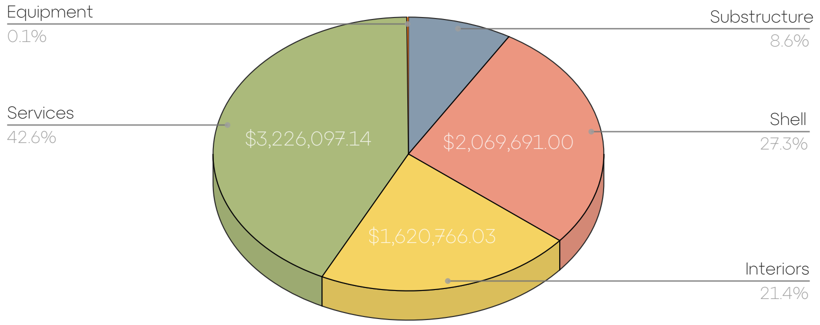
New Construction Cost Breakdown

RSMeans



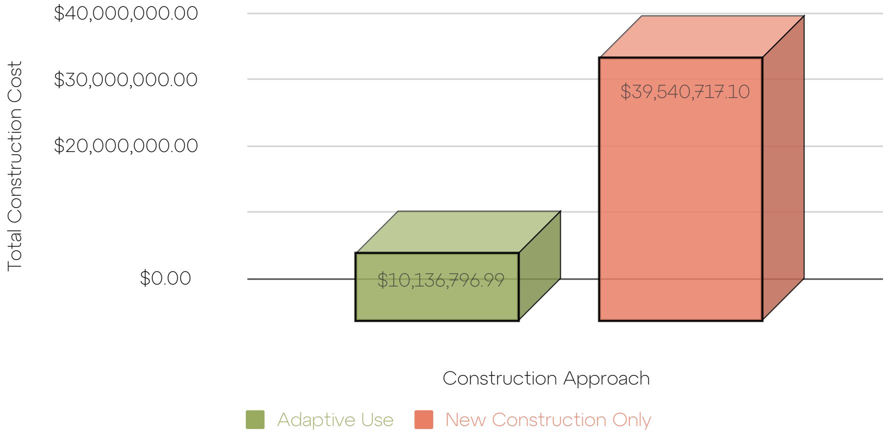
Adaptive Use Construction Cost Breakdown

RSMeans



Adaptive Use Vs. New Construction Only

RSMeans



Rubble from deconstructed wing was reused in landscaping and trombe walls

The adaptive reuse wings were lightly touched on with facade treatments while reusing 90% of existing structure

Square Foot Cost Estimate Report

Date: **4/1/2024**

Estimate Name	**Sunflower Academy 46**
Building Type	School, High, 2-3 Story (Green) with Face Brick & Concrete Block / Reinforced C
Location	NATIONAL AVERAGE
	2.00
Stories Height	15.00
Floor Area (S.F.)	104,300.00
LaborType	STD
Basement Included	No
Data Release	Year 2024 Quarter 1
Cost Per Square Foot	$262.98
Total Building Cost	**$27,429,176.95**

Costs are derived from a building model with basic components. Scope differences and market conditions can cause costs to vary significantly.

Assembly Customization Type :
- Added
- Partially Swapped
- Fully Swapped

		Quantity	% of Total	Cost Per SF	Cost
A Substructure			**4.4%**	**$8.74**	**$911,423.61**
A1010	**Standard Foundations**			**$2.30**	**$239,537.11**
	Strip footing, concrete, reinforced, load 5.1 KLF, soil bearing capacity 3 KSF, 12" deep x 24" wide	2,178.00		$1.25	**$130,680.00**
	Spread footings, 3000 PSI concrete, load 125K, soil bearing capacity 6 KSF, 5' - 0" square x 16" deep	41.72		$0.30	**$30,872.80**
	Spread footings, 3000 PSI concrete, load 200K, soil bearing capacity 6 KSF, 6' - 0" square x 20" deep	64.18		$0.75	**$77,984.31**
A1030	**Slab on Grade**			**$3.84**	**$400,512.00**
	Slab on grade, 4" thick, non industrial, reinforced, recycled plastic vapor barrier	52,150.00		$3.84	**$400,512.00**

RSMeans data

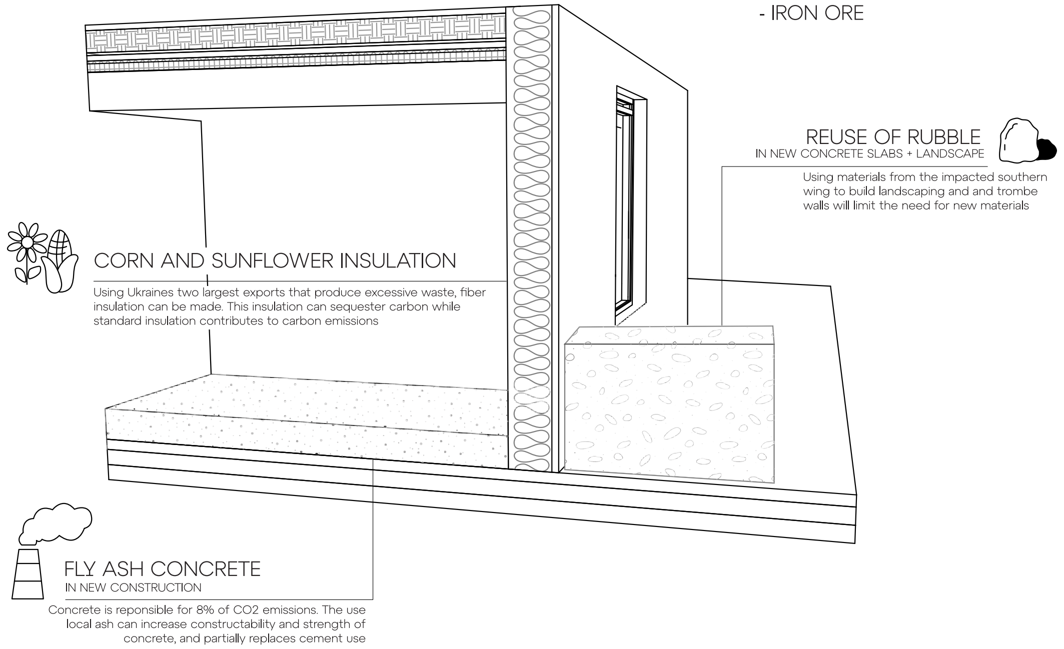
1

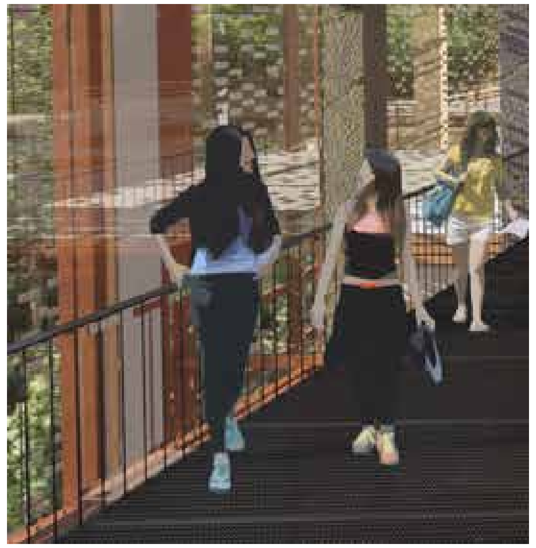
With adaptive reuse construction costs are lower and CO2 emissions are lowered. Choosing to retrofit allows familiarity for students, faculty and community as well as lower market cost allowing for an effeicent rebuild for a country rebuilding.

Using local material in our building allow for familiarity and connection to the community of Kharkiv. Using these materials also reduces carbon and cost.

Cultural Material Application

UKRAINE'S TOP EXPORTS:
- SUNFLOWER PRODUCTS
- CORN
- IRON ORE





Collaborating with students Diana Hritsay, Hanbin Guo, Maryna Meshchieriakiov, and Professor Serhii Ilchenko from the University of Kharkiv on rebuilding School 46 has been an inspiring and transformative experience. Despite the adversity faced by their community, the students from Kharkiv bring a remarkable resilience and determination to the project. We empathized with their struggle to envision a future of hope and our collaboration brought out the joy in designing for students to inhabit a school again.

REFLECTION

Thank You

U.S. Department of Energy
Solar Decathlon Organizers
Solar Decathlon Jurors

Kharkiv Academy Of Design And Arts
Professor Serhii Ilchenko
Students - Diana Hritsay, Hanbin Guo, Maryna Meshchieriakova

Ihab Elzeyadi
University of Oregon
Solar Decathalon Studio Winter 2024 and Reviewers

-

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