Retrofitting Diplomat Building

Office Building Division (OB)

University Of Art | Tehran, Iran

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

The Mehr team

CONTENTS

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Water management

Community engagement

Minimizing energy consumption

Active Facade

Optimal occupant comfort + Retaining covid restrictions

Enhanced occupant experience

locally sourced materials + using innovative materials

Electricity management

Multifunctional and flexible space

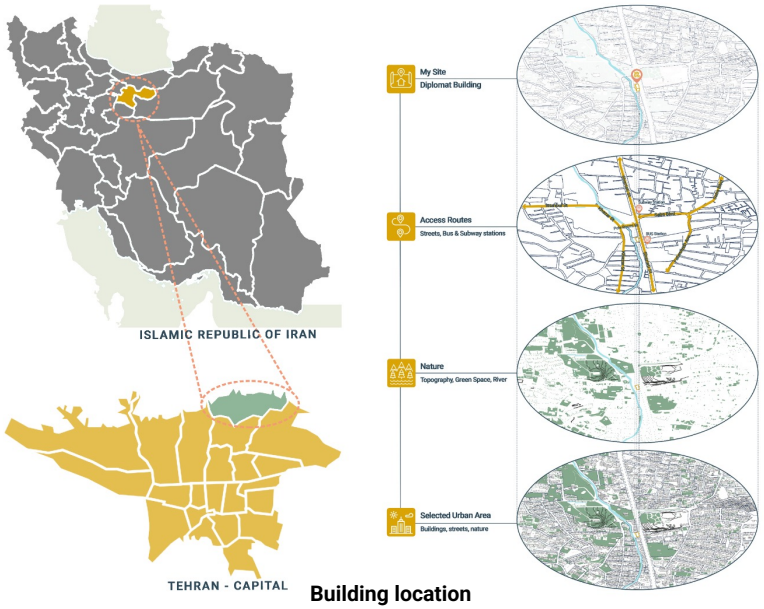
Minimizing embodied carbon + global warming potential

increasing Building Circularity + biocompatible material usage

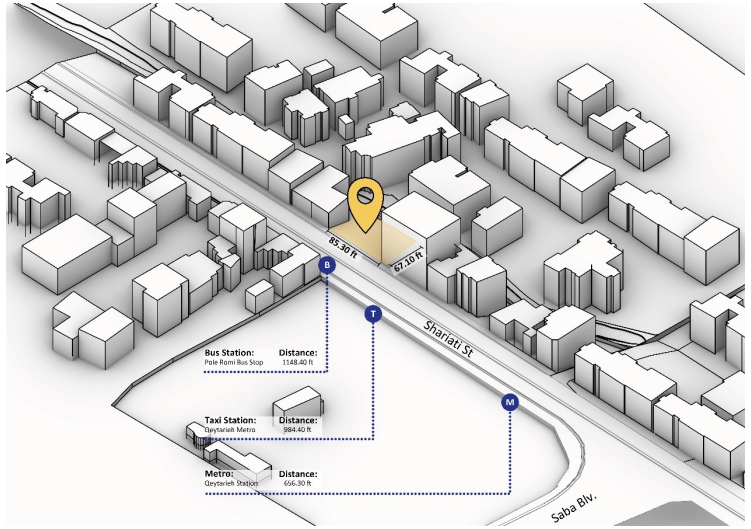
Retaining Capital

- **Software:**

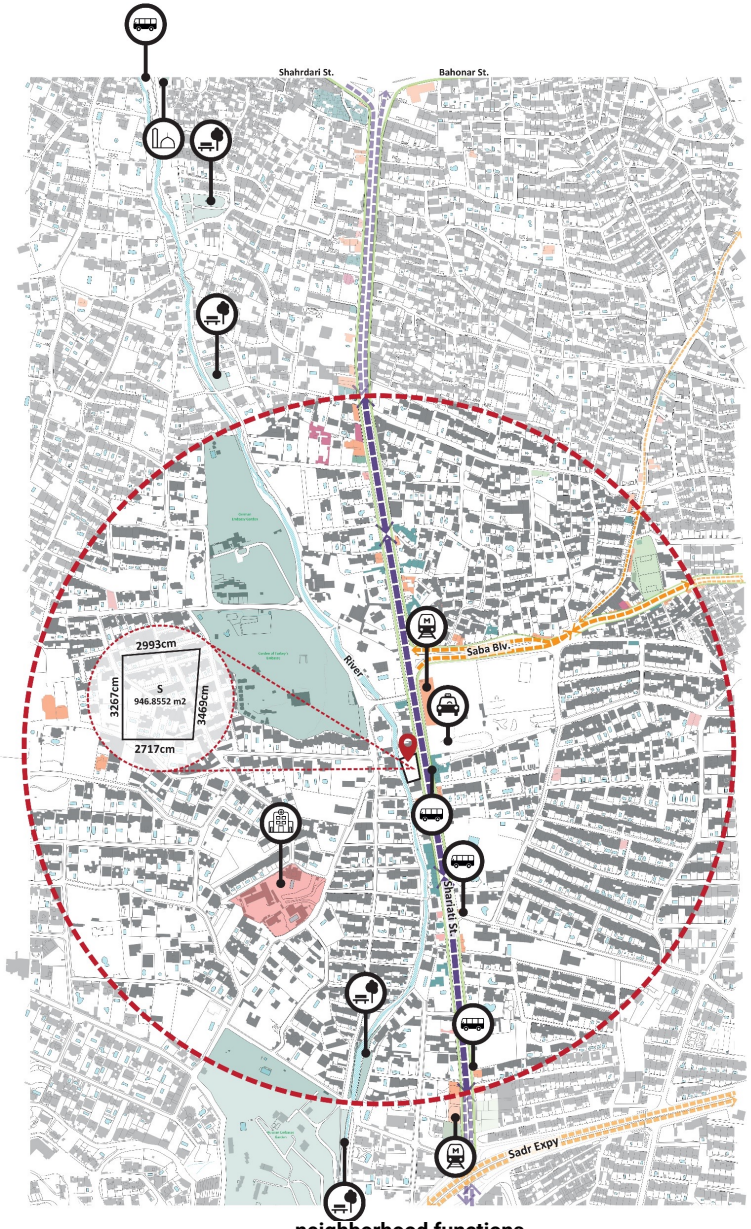
	Revit		ETABS
	Rhino		Therm
	Grasshopper		DIALux
	Lumion		MS Project
	Ladybug and Honeybee		One-Click-LCA
	TRNSYS		Oracle Crystal Ball
	Ansys Fluent		Excel
	MATLAB		Illustrator
	Odeon		Climate Studio
	Energy Plus		Design Builder



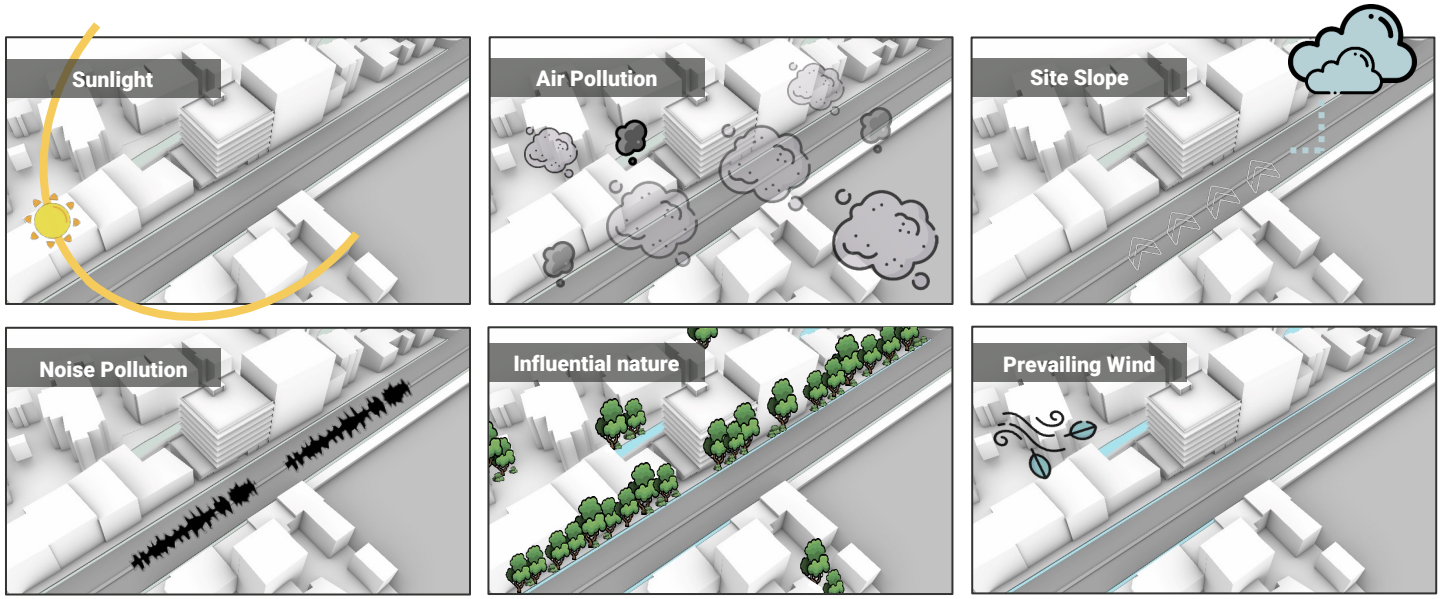
Building location



Building access

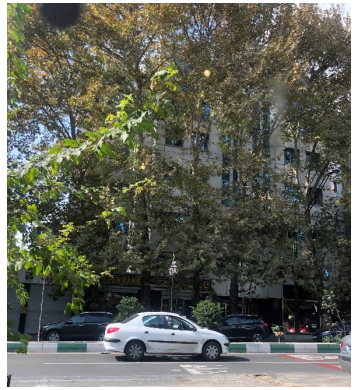


neighborhood functions

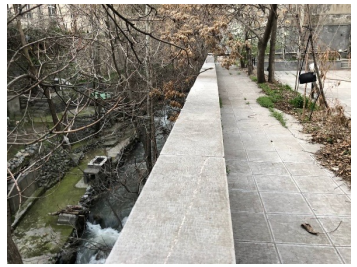


Environmental condition

East view in winter



East view in summer



River view

S

Ground slope: Maximum use of sunlight in the underground levels of the building

O

Sunlight: Optimum use of the sun for solar panels on the roof and facade

Nearby landscape: Providing a pleasing view for users and reducing glare

River: operation in mechanical facilities of the building, attention to the existing capabilities of the river in designing staff rest areas

W

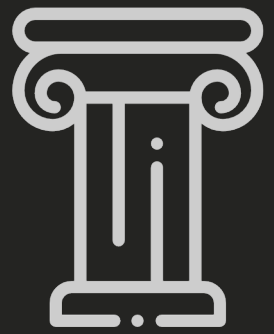
Ground slope: Inability to use the ramp to access the lower floors due to the slope

T

- Air pollution: Proper ventilation can reduce the need for users to open windows
- Noise pollution: The use of new materials and the design of the building envelope to maximize sound transmission to space
- The building is located in a densely populated area and construction-related transportation is limited

5.

1



Architecture

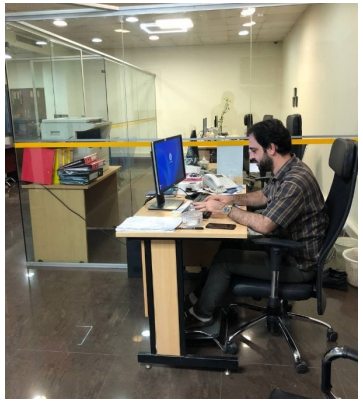
- **Existing occupant :**

Building owner:

In each of the office floors, there are 4 separate units with different uses that have not helped to strengthen and complete each other. Also, there is no direct interaction between the people of the neighborhood and the building staff. Ground floor business units do not create an invitation and participation space for people in the neighborhood.

Employee:

Spaces such as the library, lounge, coffee shop, etc; do not exist and this causes the residents to feel exhausted after working for a short period of time, therefore the quality of their work reduces tremendously. Although there is a river adjacent to the building, it is not possible to exploit its potential.



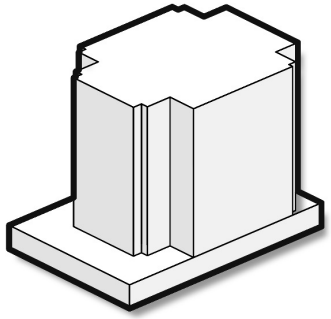
Employee:

Not having an optimal air conditioning system or a mechanical system with fresh air and ignoring the importance of indoor health and covid-19 protective measures have limited the possibility of face-to-face communication.

Employee:

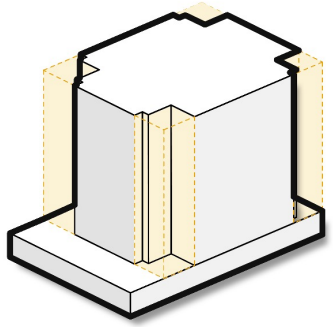
Light discomfort is felt, Such as glare in some places like on the monitor or working plane and lack of daylight.

- **Design process:**



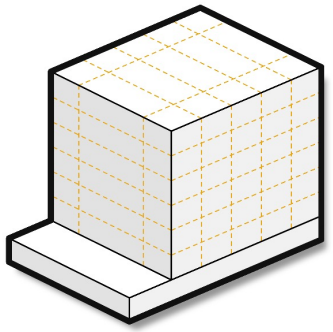
1. Basic Building

Diplomat Building, the building on which the design is based.



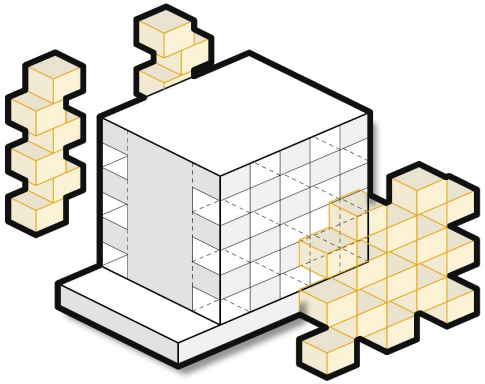
2. Add

The base building became a complete cube with the addition of sections to the 4 corners of the form.



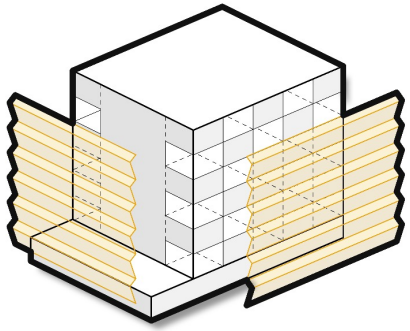
3. Divide

The building was then divided into sections to form a design concept.



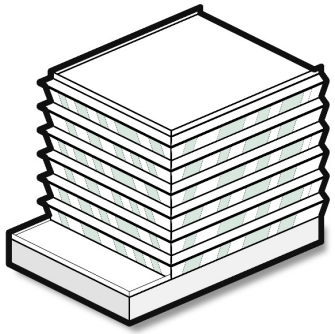
4. Reduce

Parts were reduced to diminish the rigidity of the space and increase the flexibility of the volume (Glass Cabin).



5. Facade

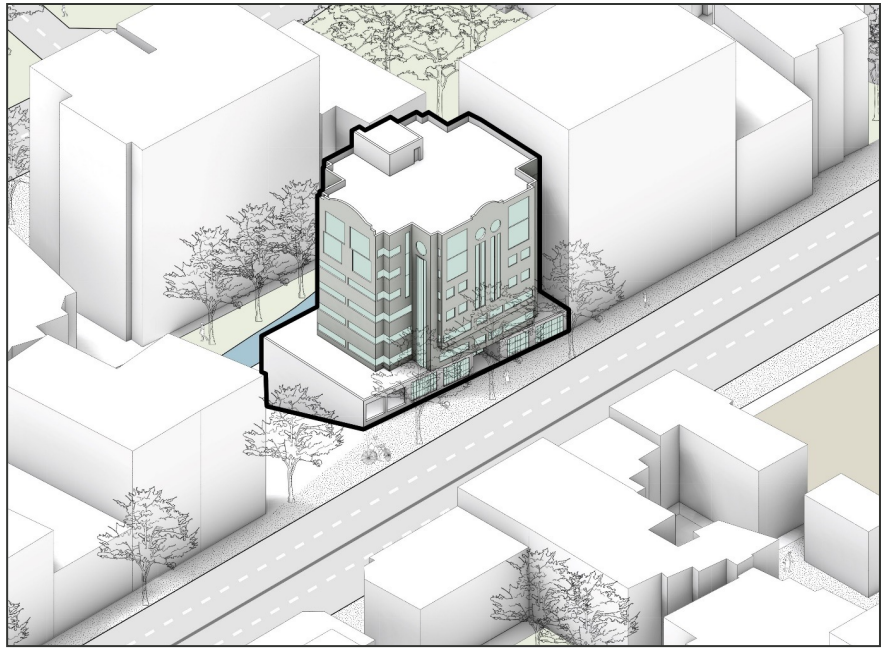
A glass facade with a PV was added to the southern part. The same pattern was repeated for Eastern and Western to further match the views.



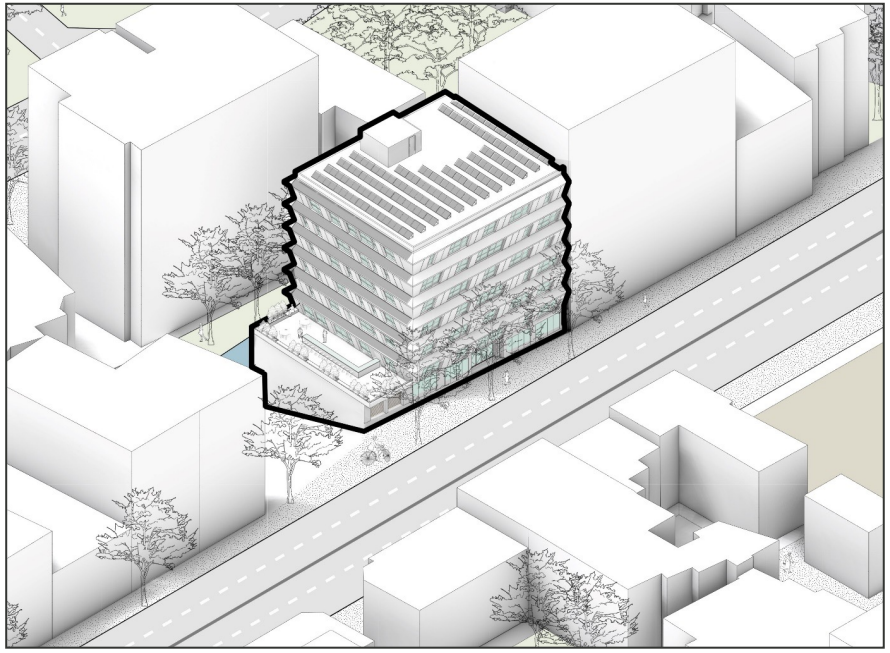
6. Final Building

Due to the function of the interior spaces and the amount of daylight required, parts of glass wall were turned into walls.

- **Façade Design:**



Existing Building



Redesign Building

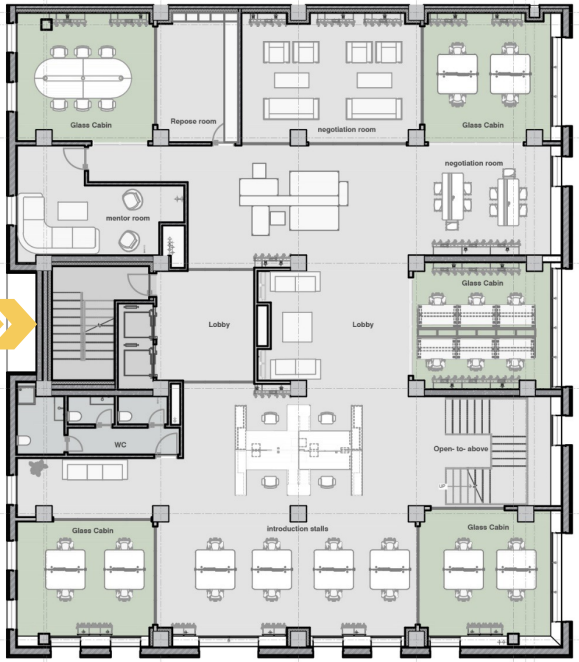
Existing Building

Redesign Building

- **Floor Plans Design:**

Existing Plan

Zones in Redesign Plan

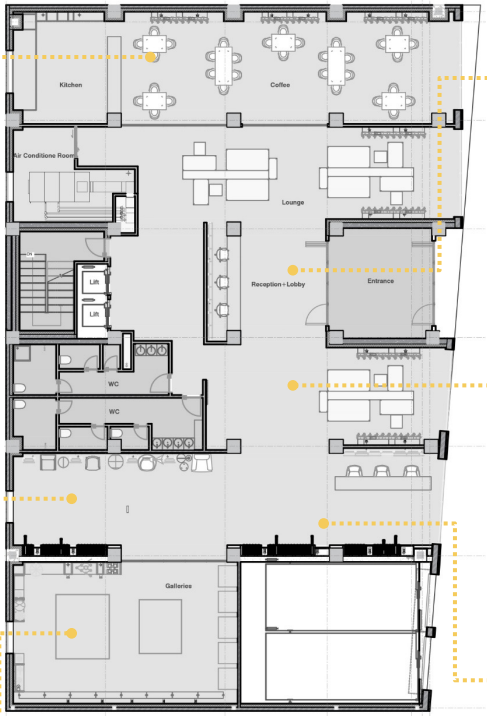


Redesign Plan

Coffee Shop

Furniture Showroom

Furniture Showroom



Ground floor plan

Lobby

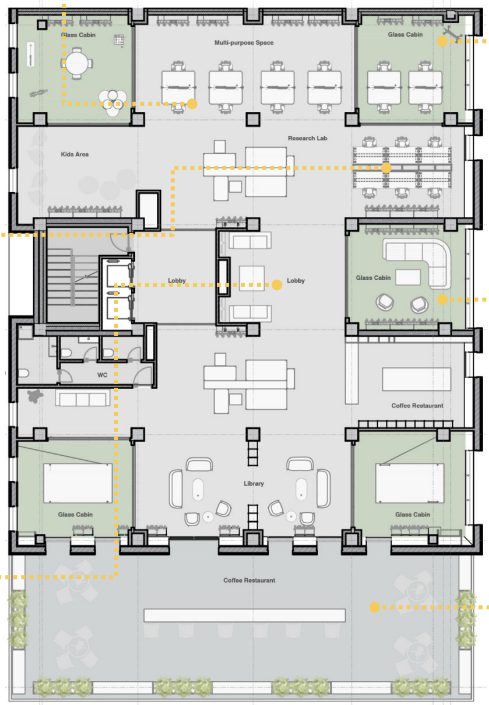
Product Introduction Section

Material
Showroom


Co-Working space

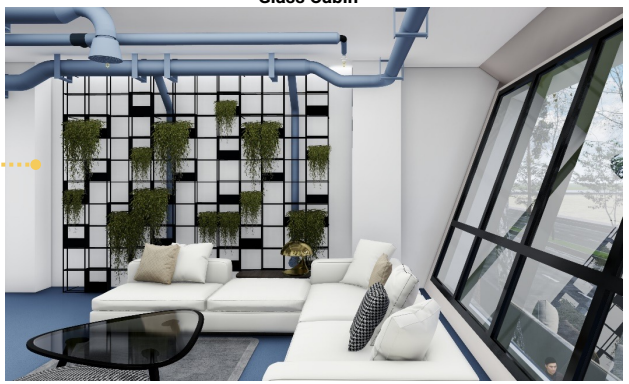

Research Lab


Lobby



First floor plan

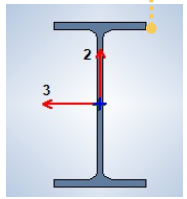

Glass Cabin


Glass Cabin

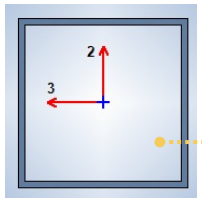

Terrace

5.2 Engineering

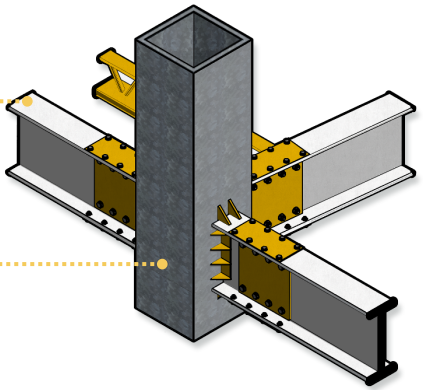
- **Structural analysis:**



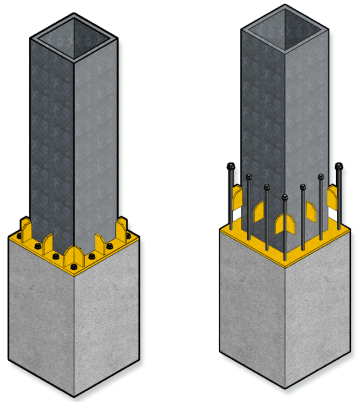
box 400x400x15



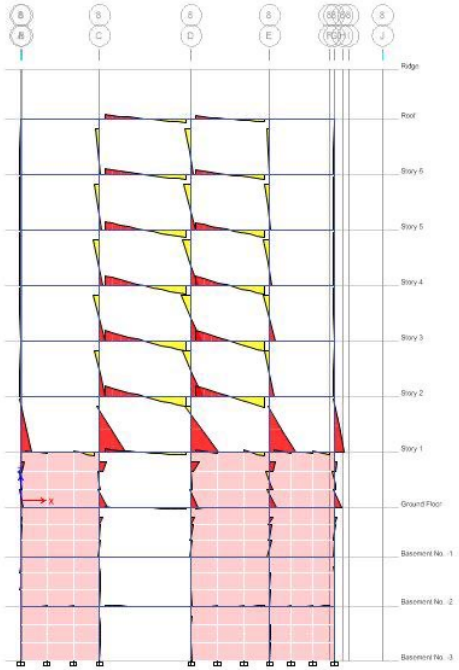
IPE 140



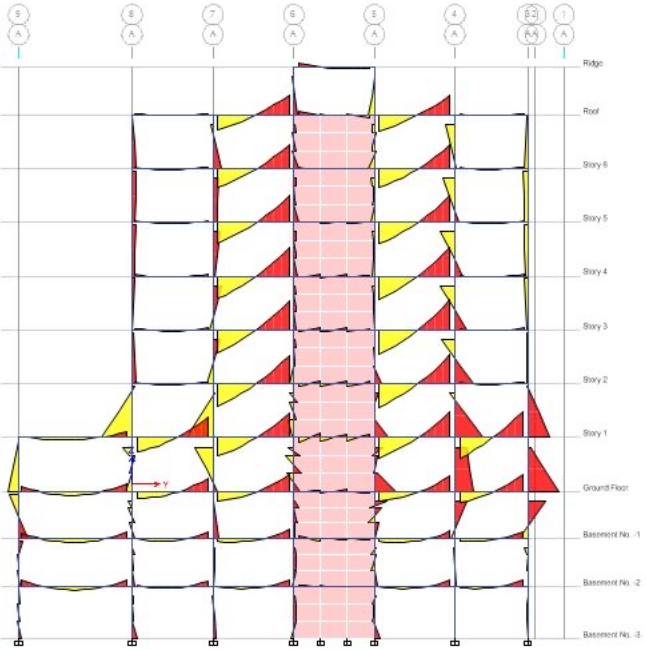
Joint beam to metal column



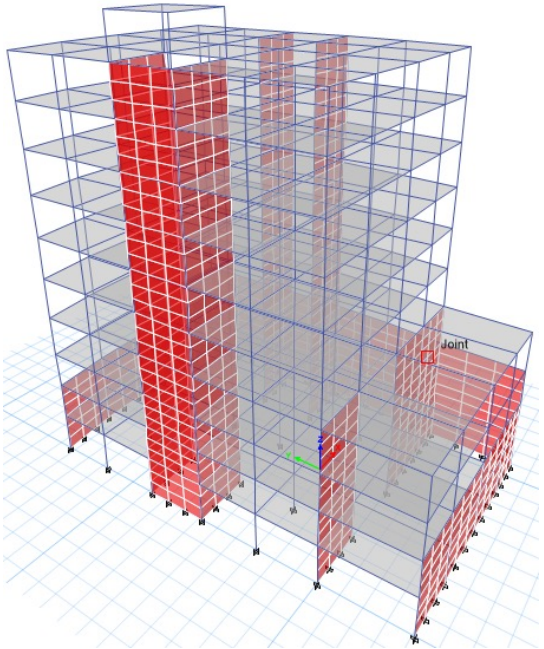
Joint concrete column to metal column



Force distribution in the south view

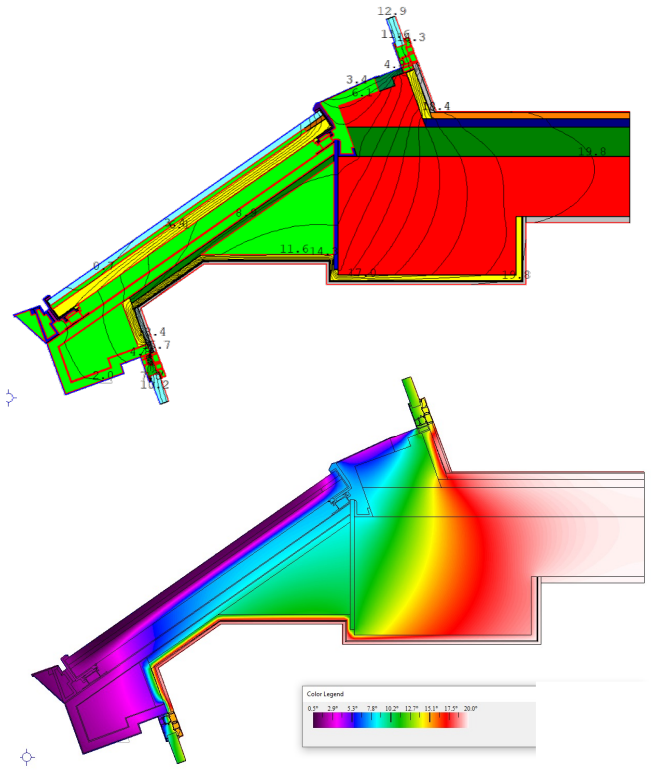


Force distribution in the east view

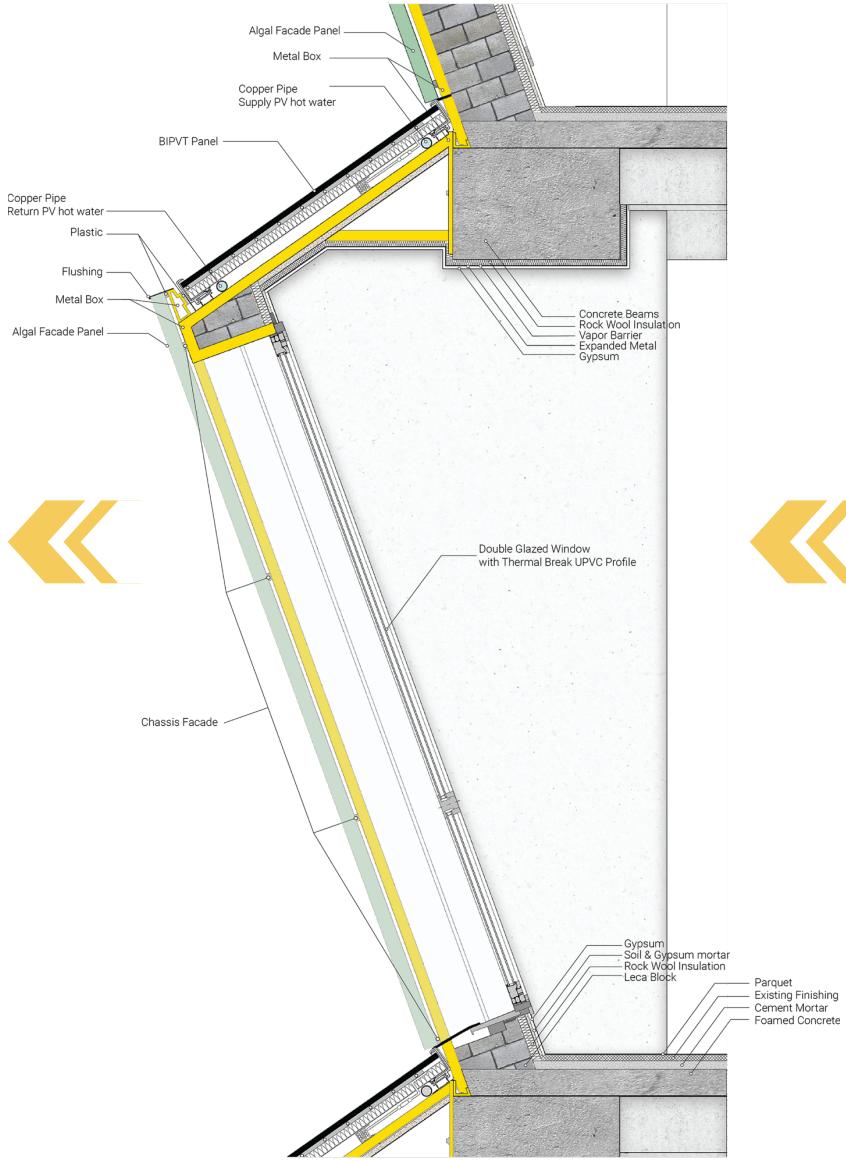


Etabs model

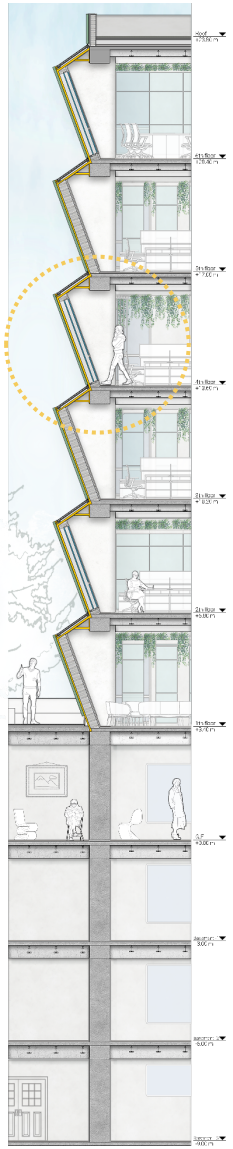
- **Structure & Envelope:**



Therm analysis

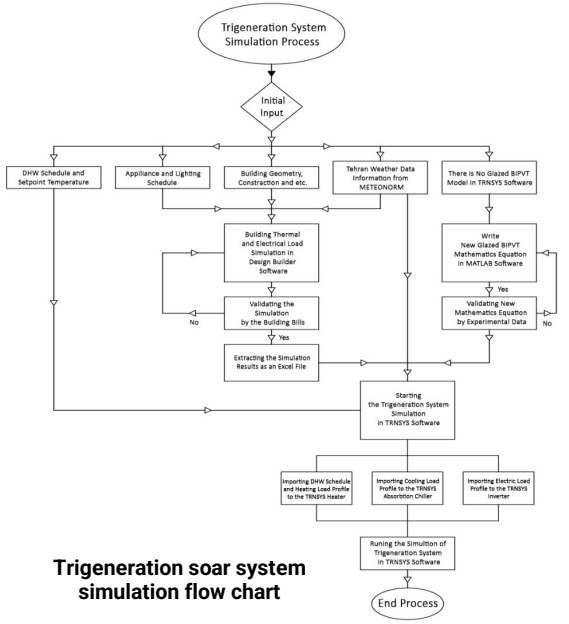


Callout for solar heating panels

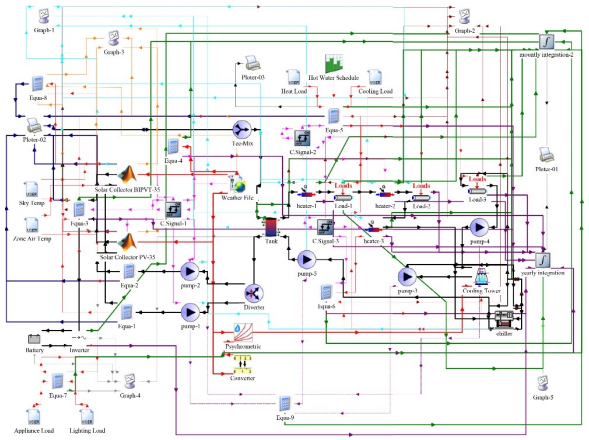


Wall section

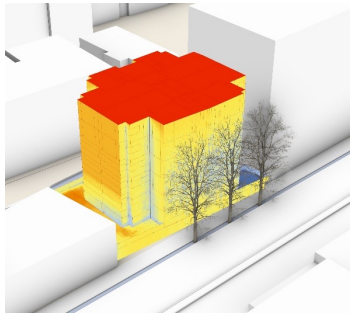
- ## Solar System:



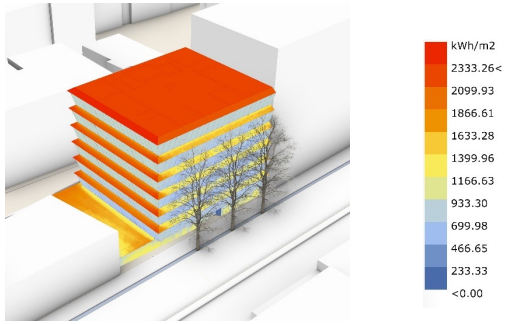
Trigeneration soar system simulation flow chart



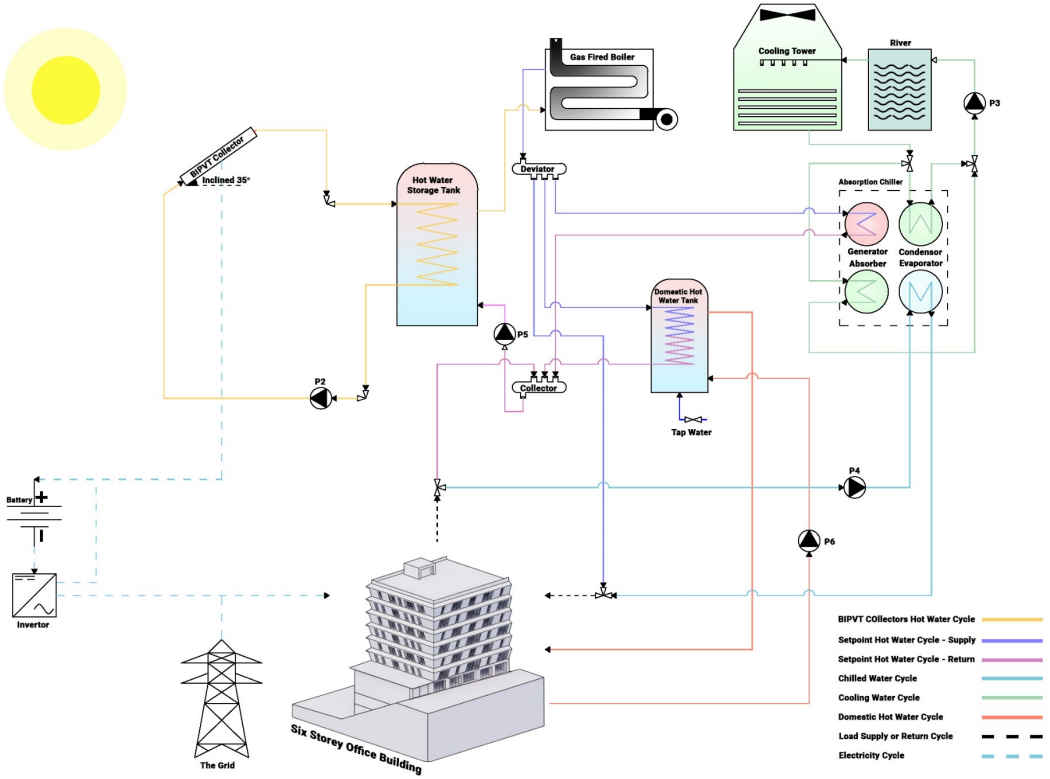
The TRNSYS model of the proposed trigeneration system



The annual radiation of existing building

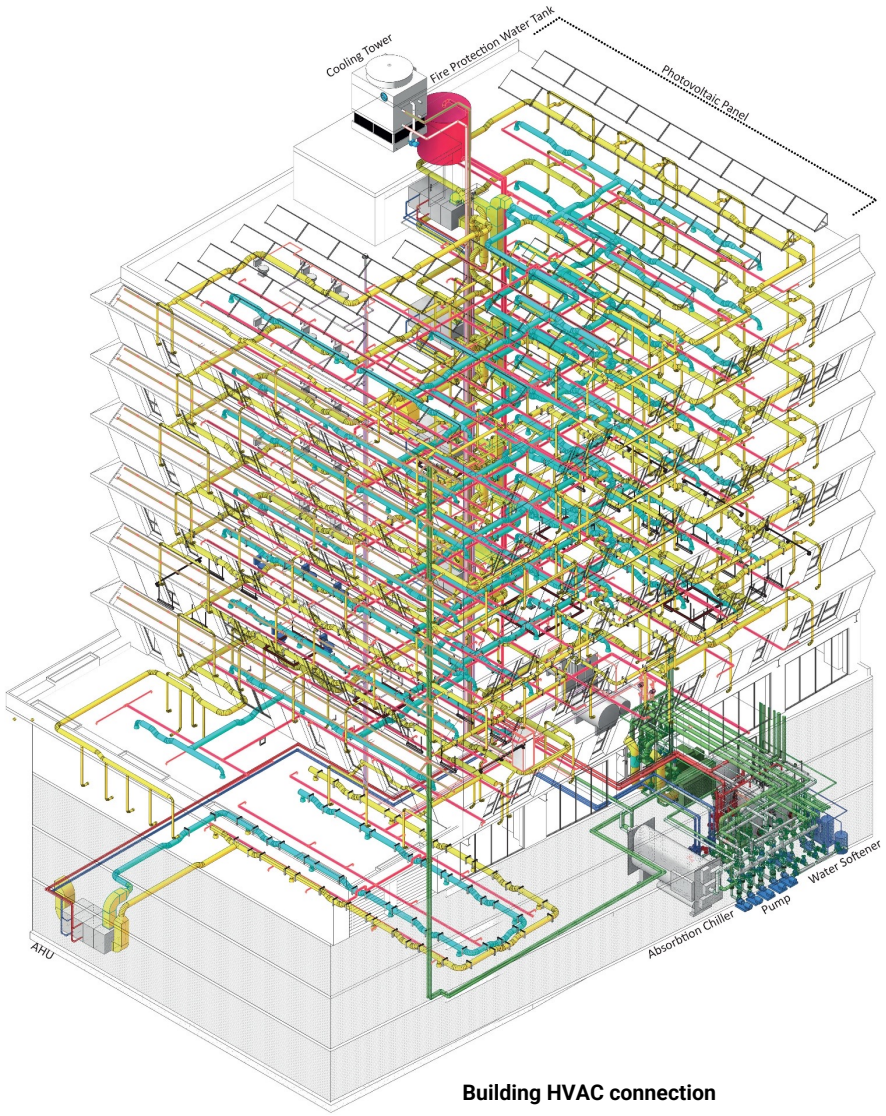


The annual radiation on PVT and BIPVT

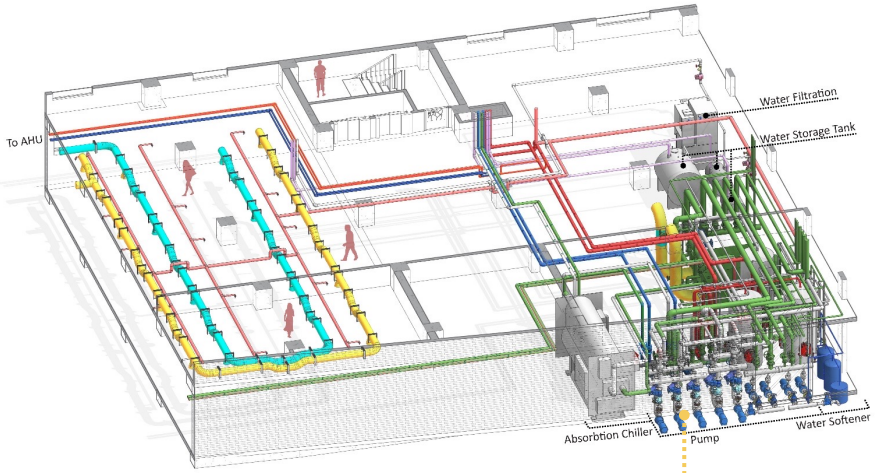


Trigeneration solar system diagram

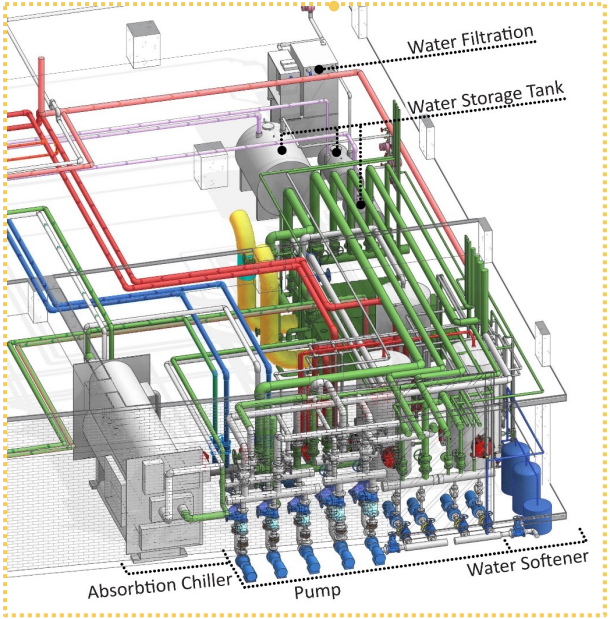
- **Mechanical System and Plumbing:**



Building HVAC connection



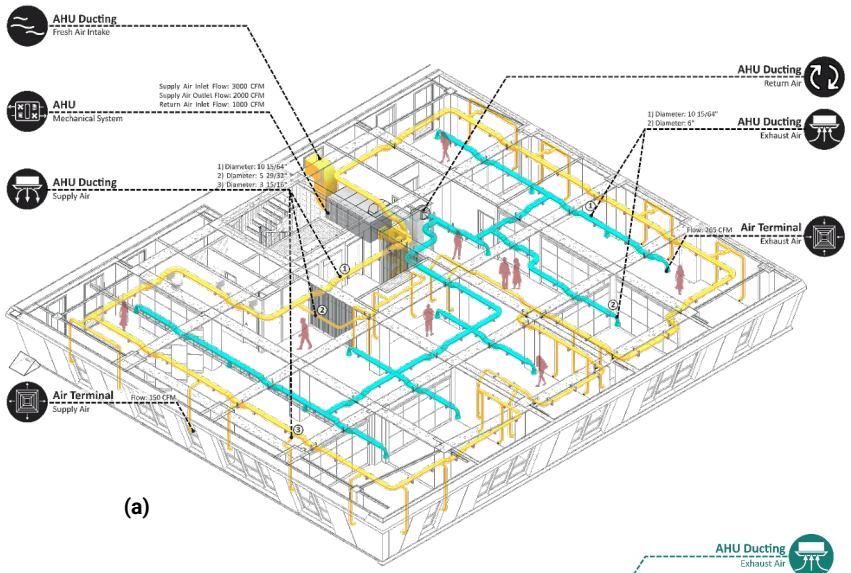
Mechanical room

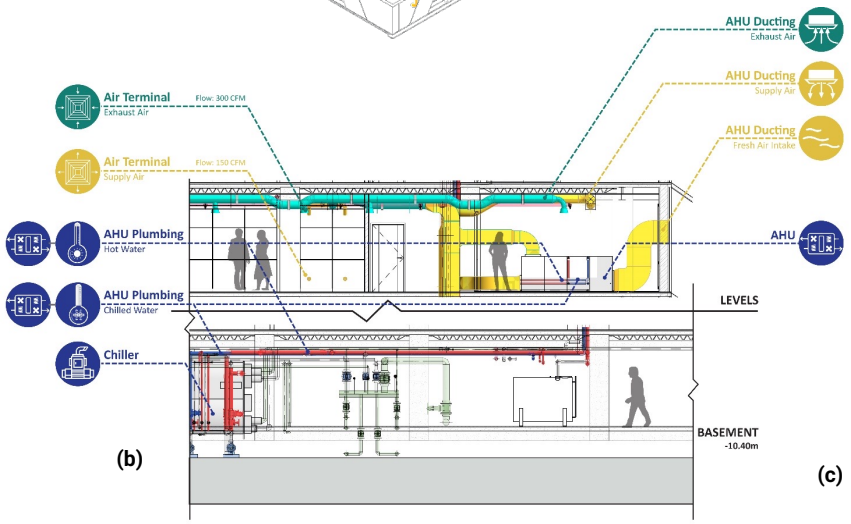


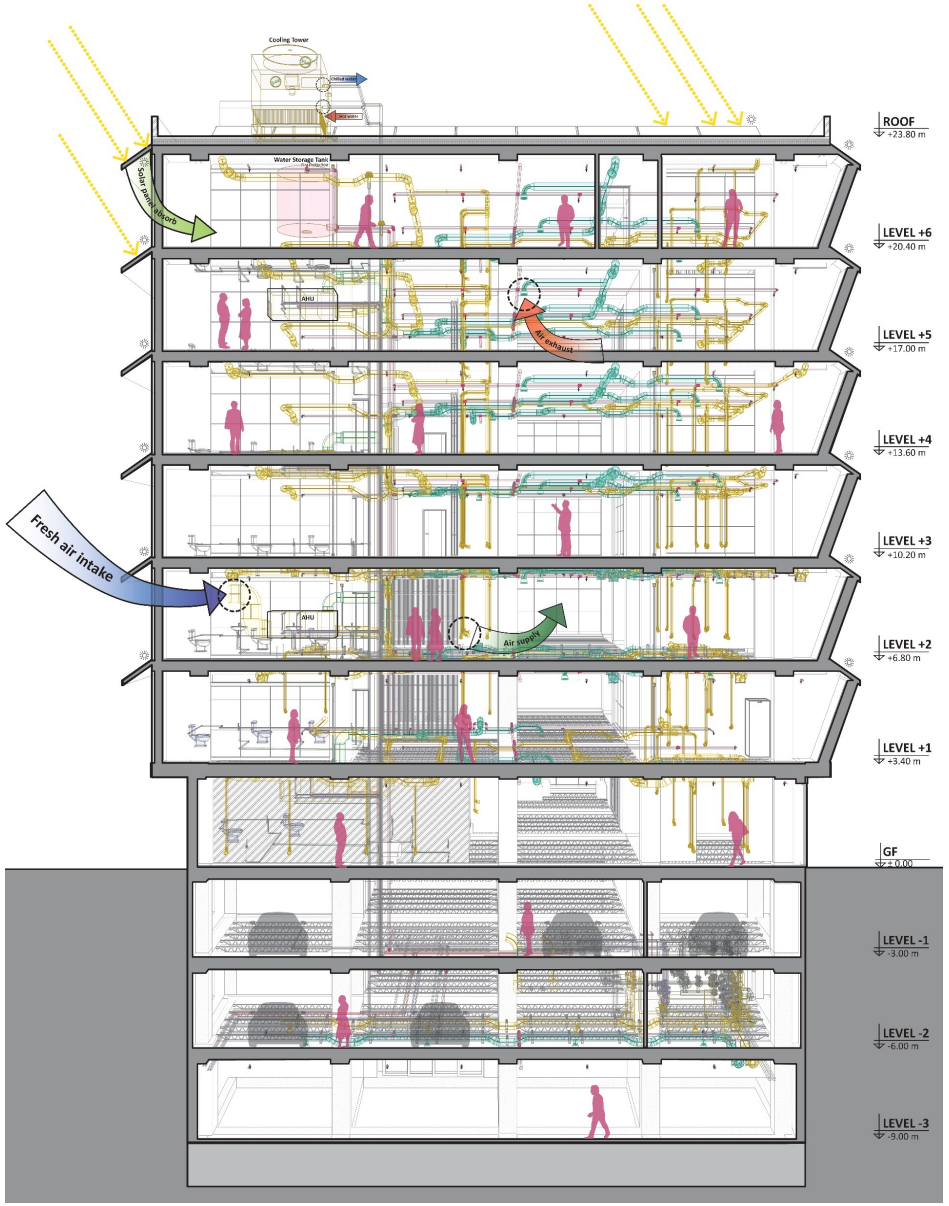
LEGEND

- Grey Water Plumbing
- AHU Supply Air Ducting
- AHU Exhaust Air Ducting
- AHU Hot Water Plumbing
- AHU Chilled Water Plumbing
- Fire Protection Plumbing
- Solar Thermal Plumbing

- **HVAC System:**





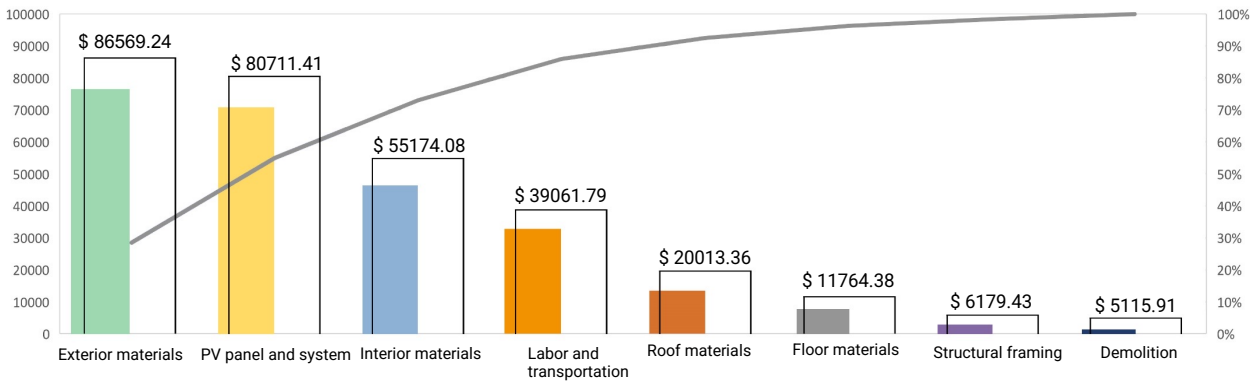


Air handling unit supply and exhaust ducts : (a) Perspective view, (b) Section view, (c) Perspective section

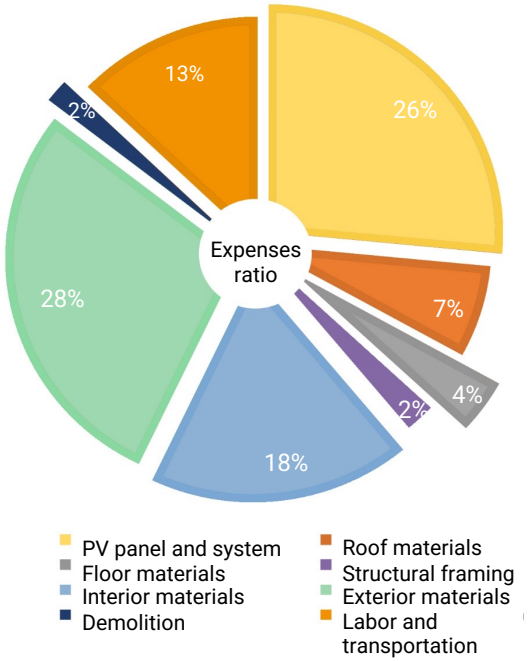
5.

3

Market Analysis



Estimated budget

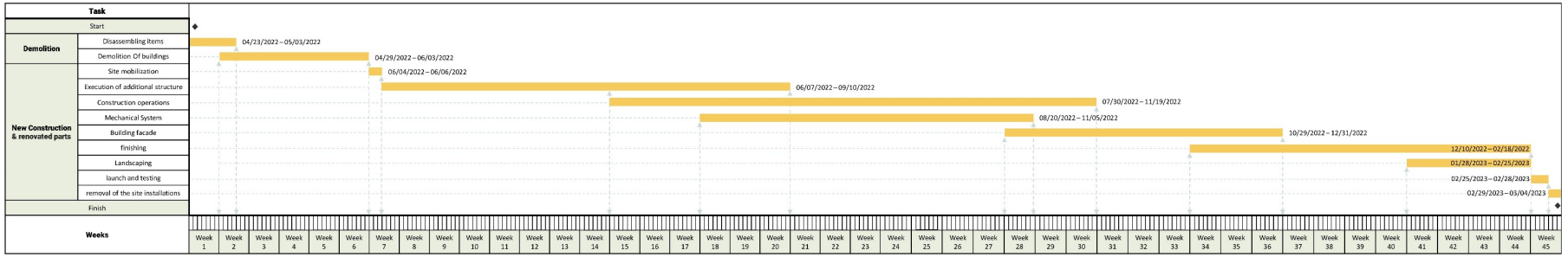


Expenses ratio

Demolition: $ 5,115.91
New Construction & renovated parts: $ 260,411.94
Total Renovation costs: $ 304,589.65

Total savings: $ 53,983.03 per year

Payback Period: after 6.1 years

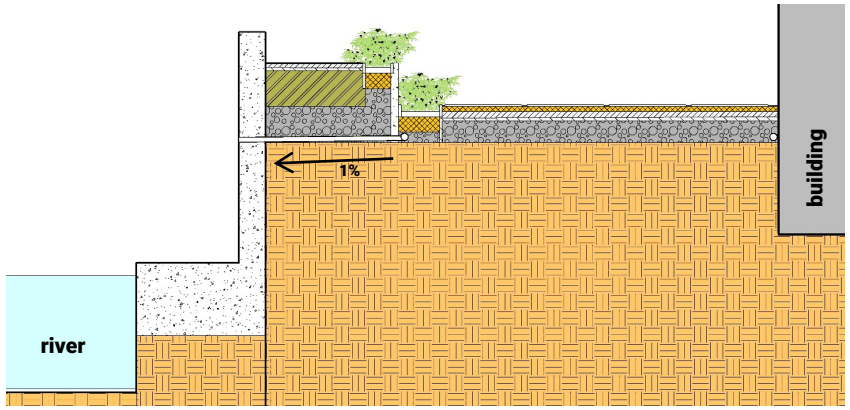


Overall plan

5.

4

Durability and Resilience



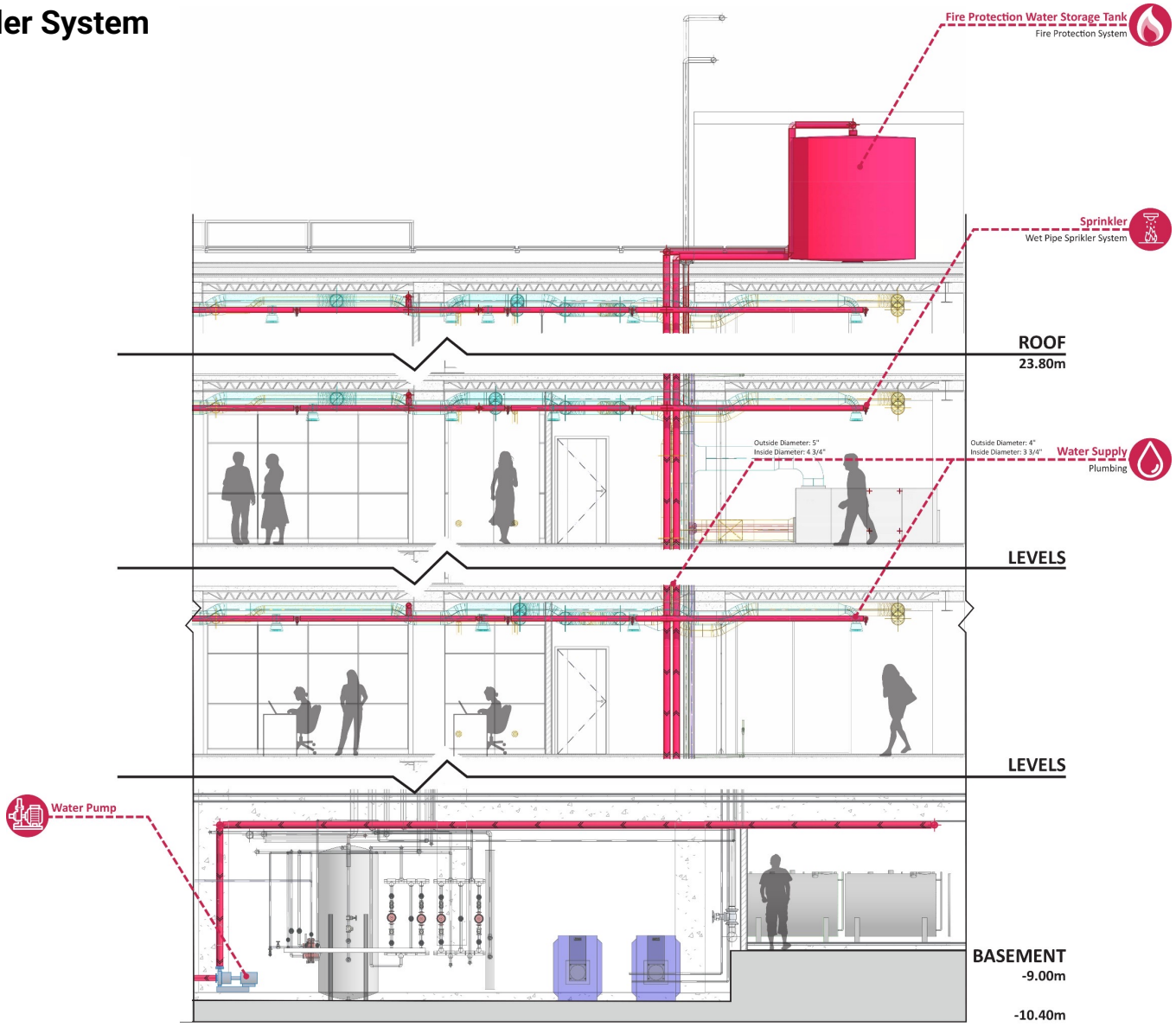
Detail of rainwater collection

Existing yard

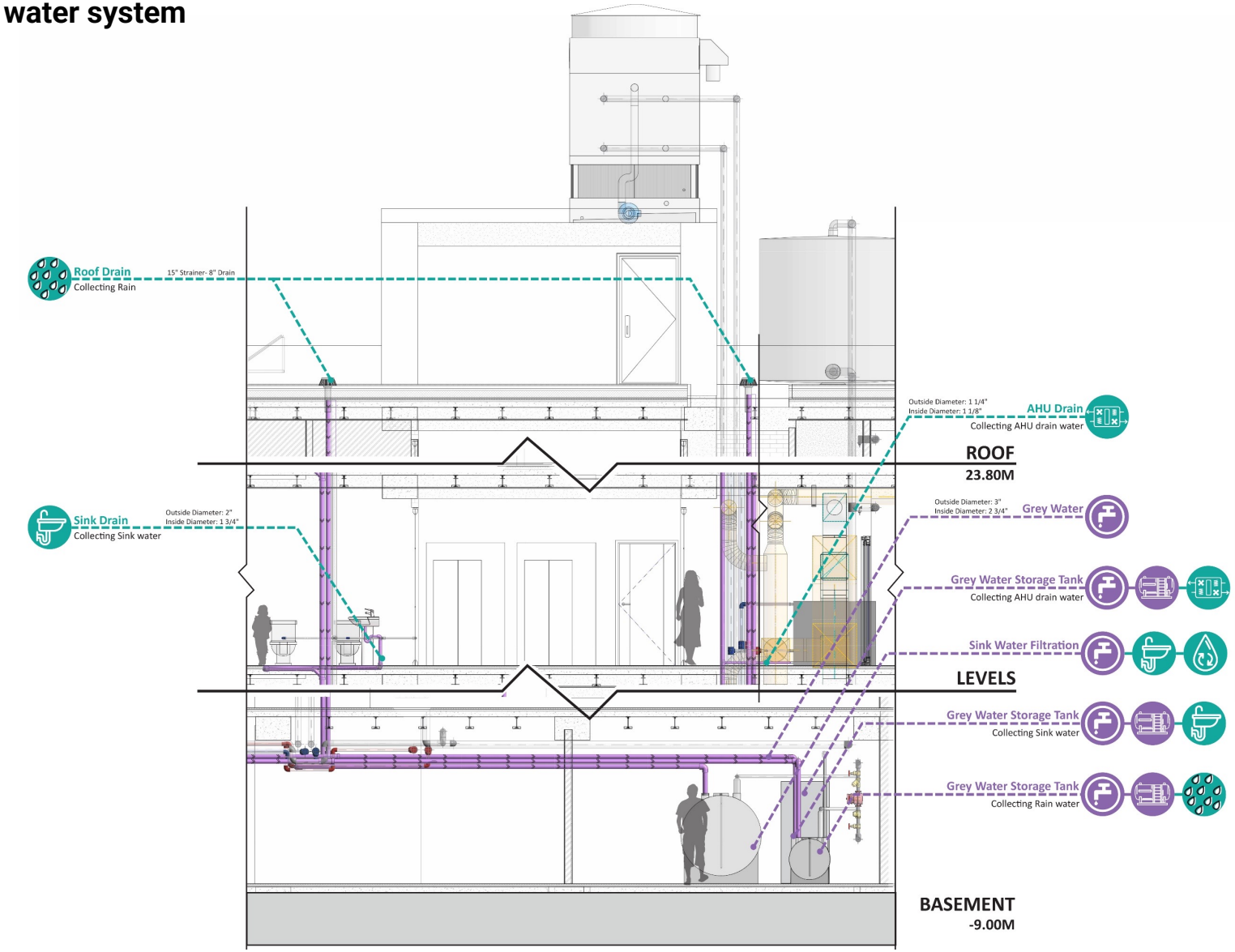
The render of yard

The render of river view

- **Sprinkler System**



- **Gray water system**



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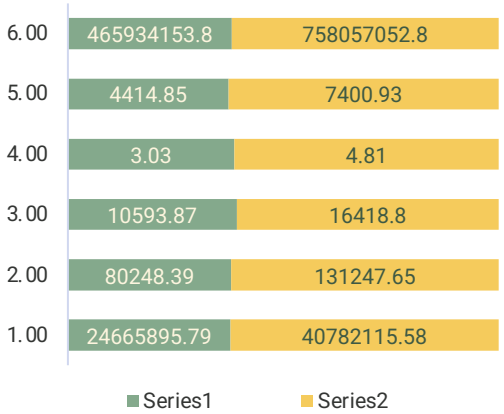
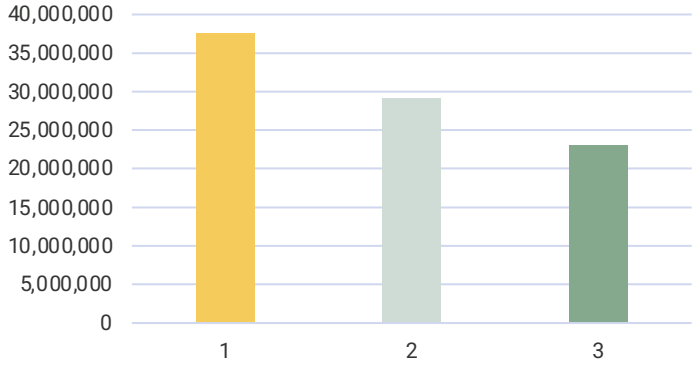
Embodied Environmental Impact

- ## Carbon Reduction and Net Carbon Design



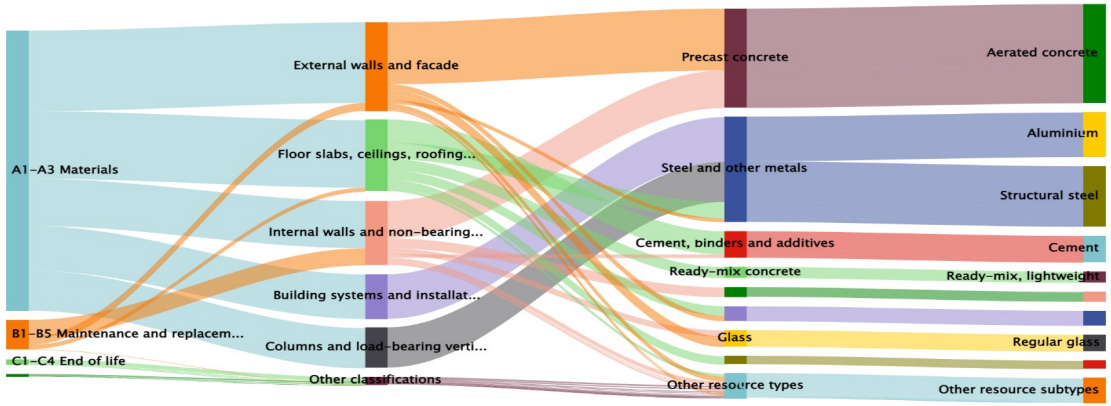
Life-cycle assessment, EN-15978 in Energy use (B6 Level)

This diagram shows that in almost all six categories of environmental impacts, such as GWP, AP, EP, and ODP, the rate of damage has reached **half of the previous** environmental impacts.

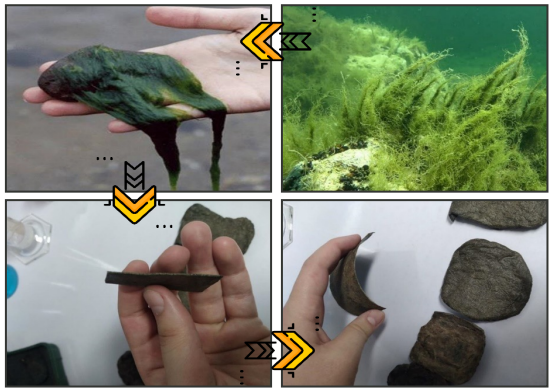


Net Carbon kg CO2e (B6 level)

the kg CO2e in phase B6, which is related to annual energy consumption, is approximately **31%** lower in the regenerative state, excluding the solar energy produced by the building. Also, considering the Exported Energy sector, this reconstruction has been able to show **47%** in the Net Carbon sector of optimal behavior compared to the base building.

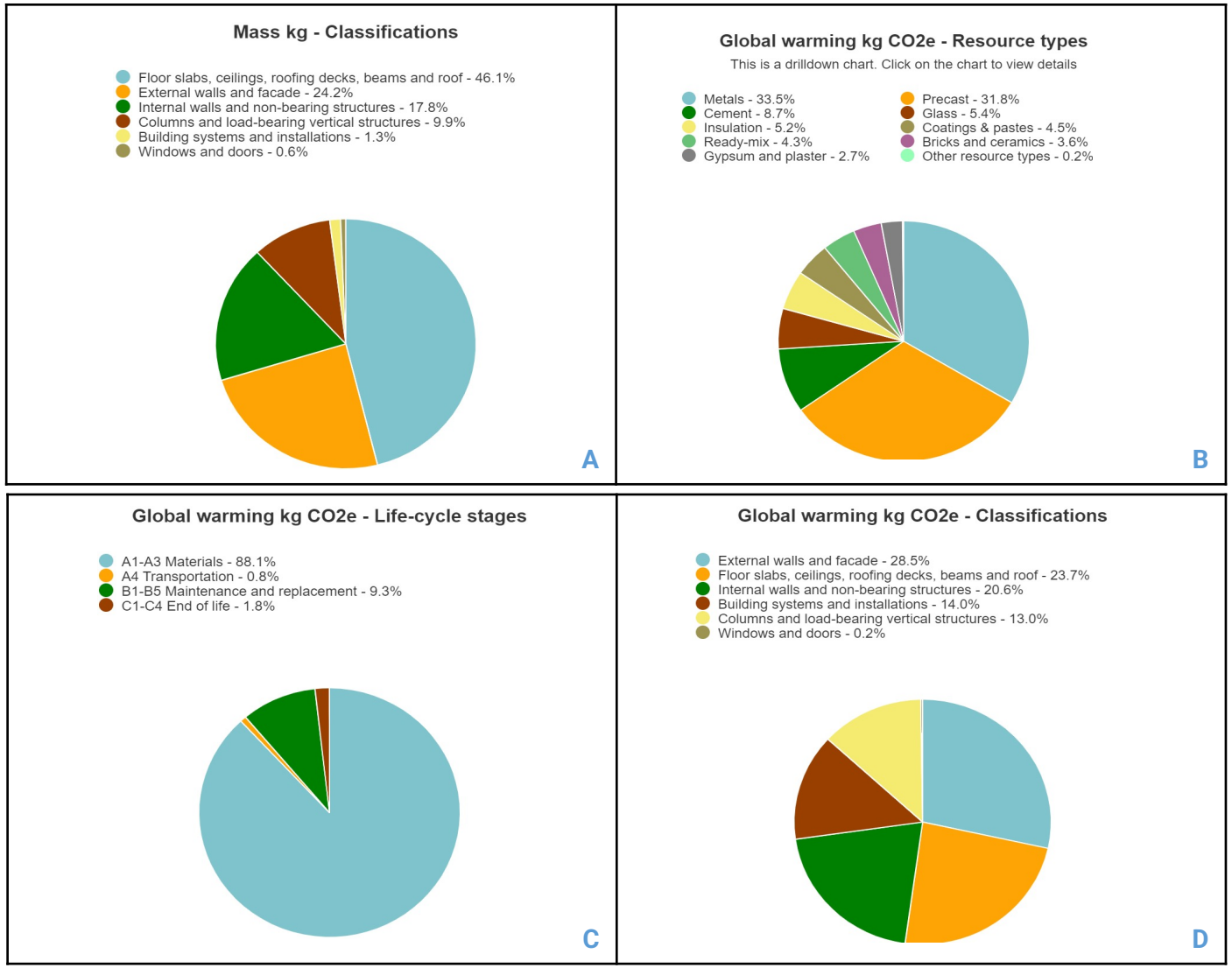


Sankey diagram, Global Warming Potential in construction materials



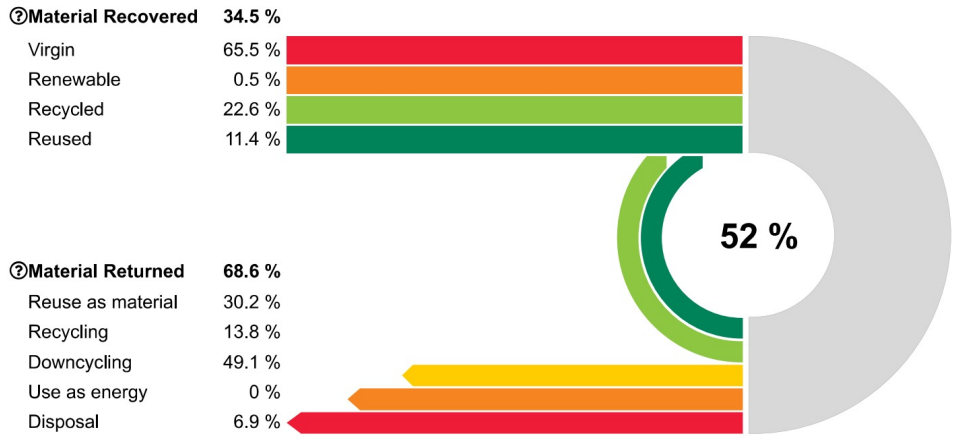
Using biocompatible material: Algae-based coating

- **Life Cycle Assessment (Building Construction)**



Life-cycle overview of Global warming

- ## Circular Economy and Regenerative Design



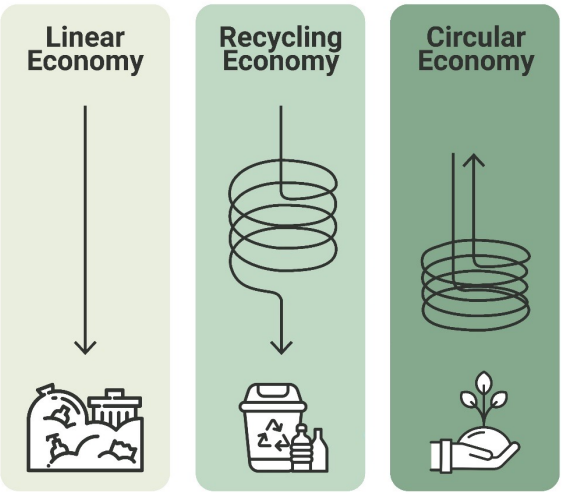
Analyzing the building circularity index of the optimized office building during the retrofit phase

We can use some solutions like the design for disassembly, reusable materials, and biocompatible materials to increase the circularity index.

Toward Circularity

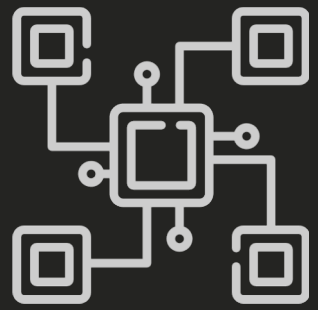
This project identifies four design models that use practical tools to rethink and redesign products and services for the circular economy:

1. Design for longevity
2. Design for leasing or service
3. Design for re-use in manufacture
4. Design for material recovery



Linear, Recycling, and Circular Economy differences

5. 6



Integrated Performance

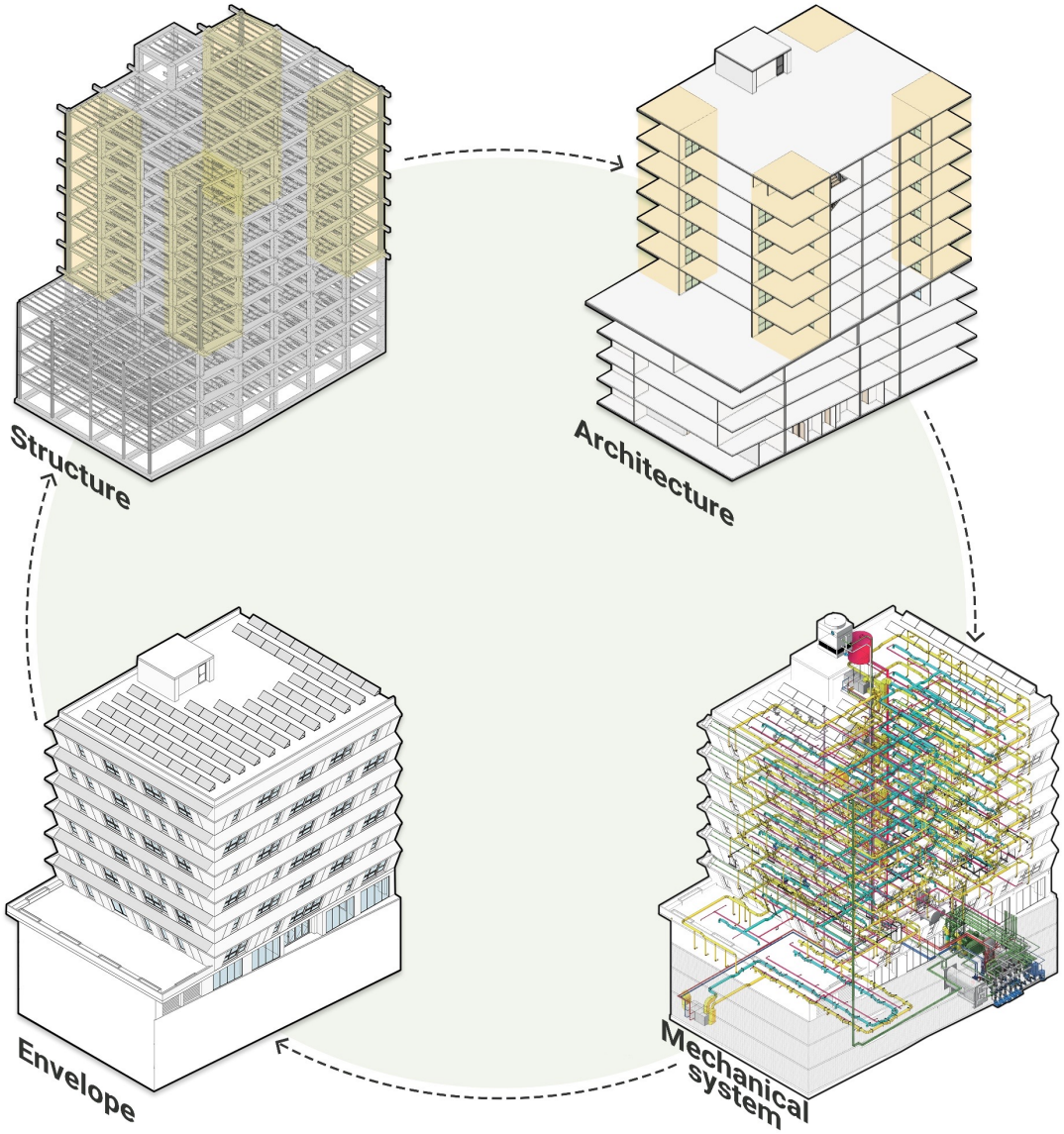
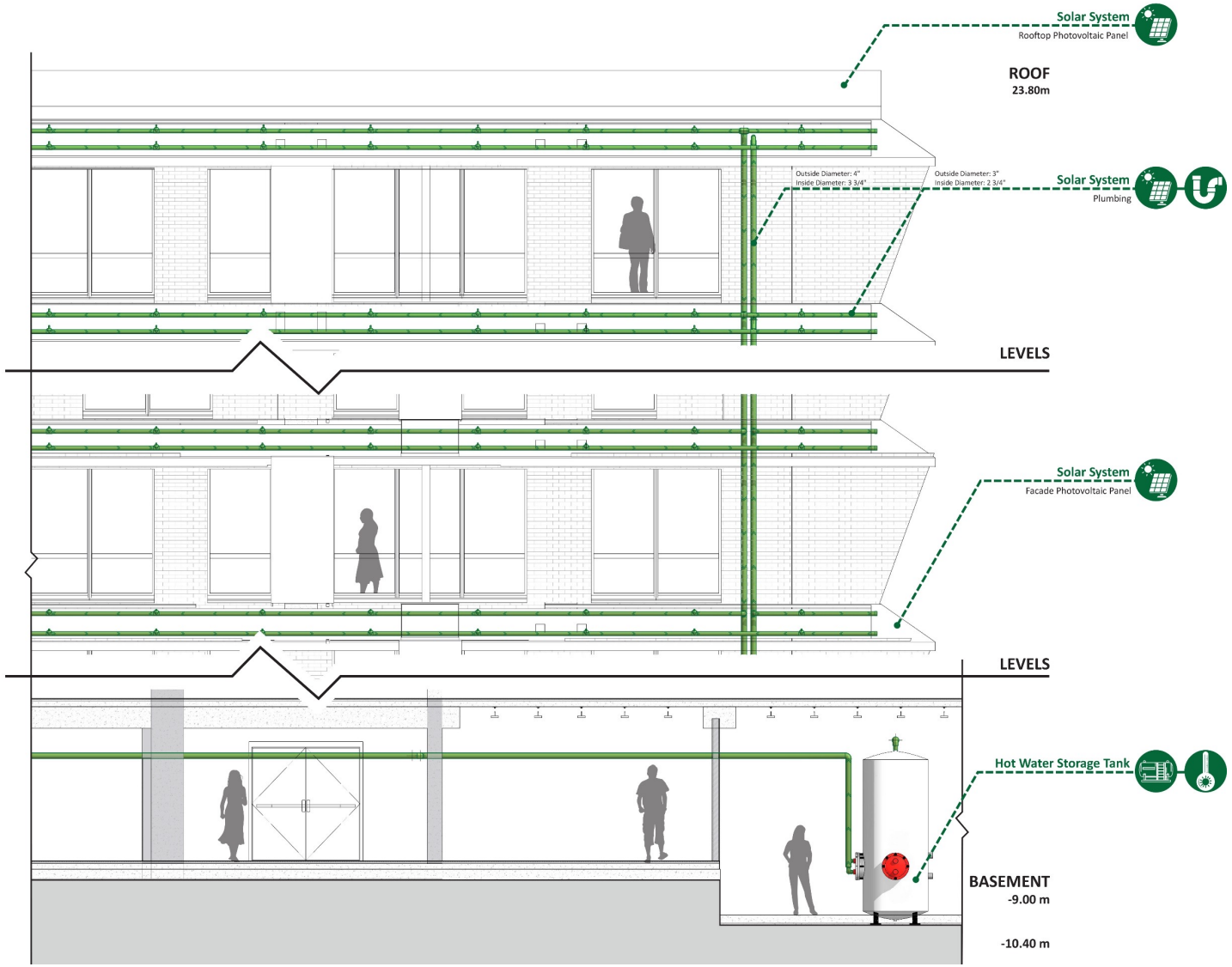


Diagram of the integrity of all parts of the building

- **Integration of the solar system with mechanical installations**

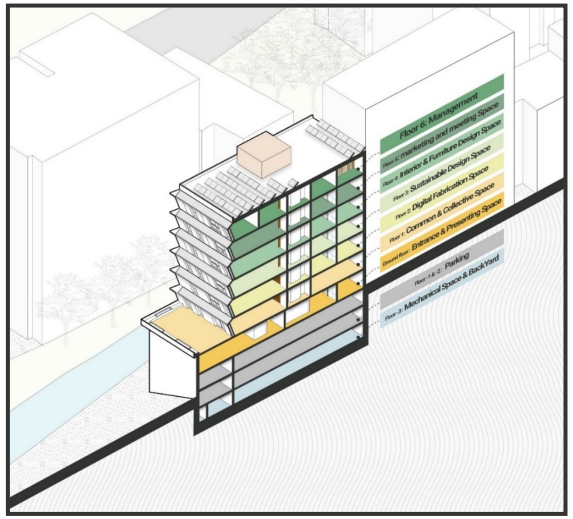


5. 7

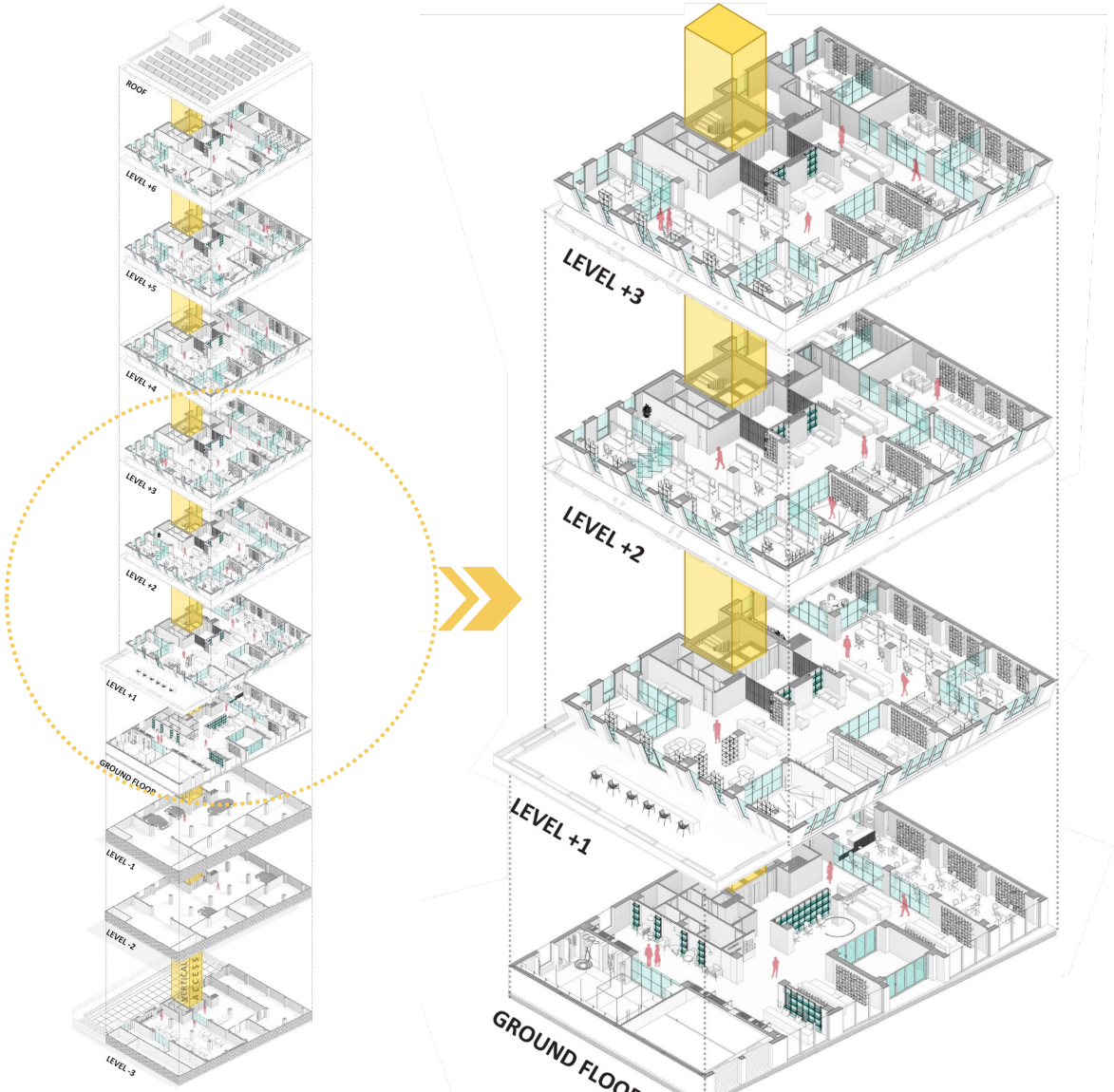
Occupant Experience

Building's function:

The function of each space



The Function of each floor

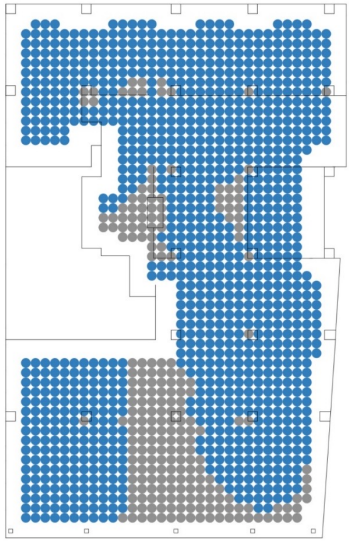


Exploded plans

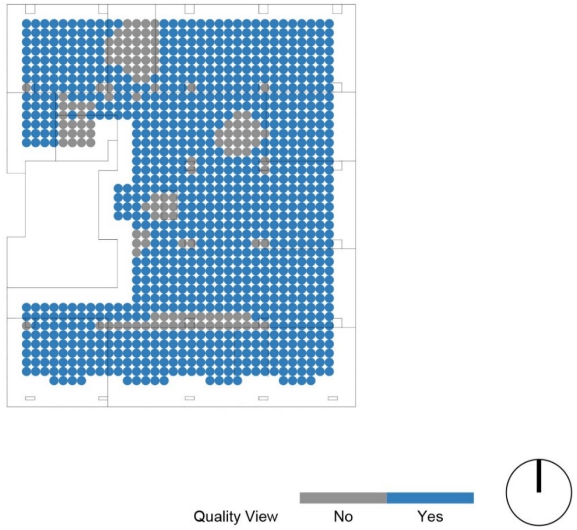
- **Flexible furniture**

- **Flexible Glass cabins**

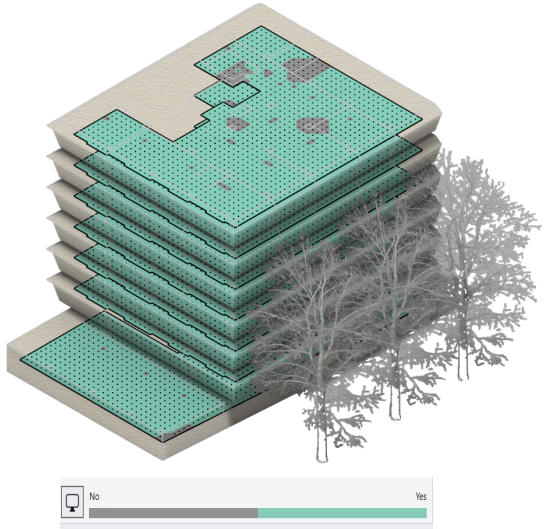
- **Occupant's Views:**



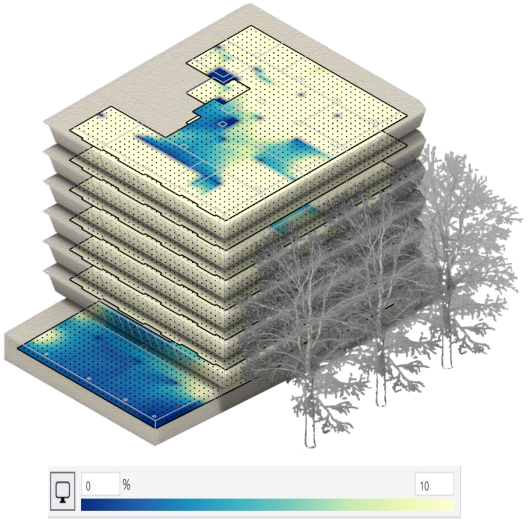
View analysis of Ground floor



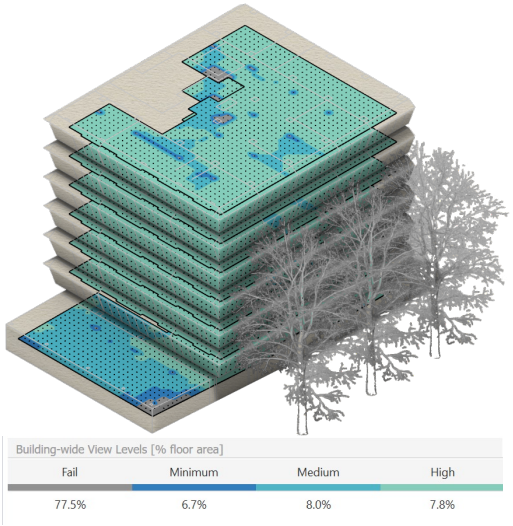
View analysis of Floorplans(uppermost level)



Leed standards

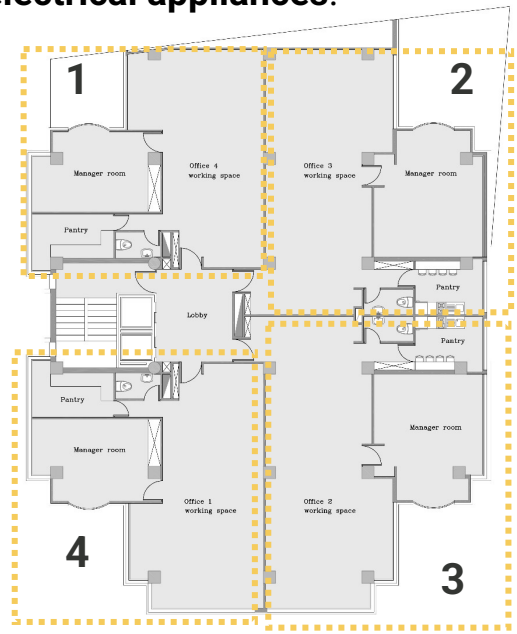


Avg.Distance: 4.5 m



EN 17037 standards (horizontal sight angle)

- **Integration of electrical appliances:**



Existing plan for +2 floor

New plan for +2 floor

- **Appliances for Occupant comfort:**

○ **Light sensor:**

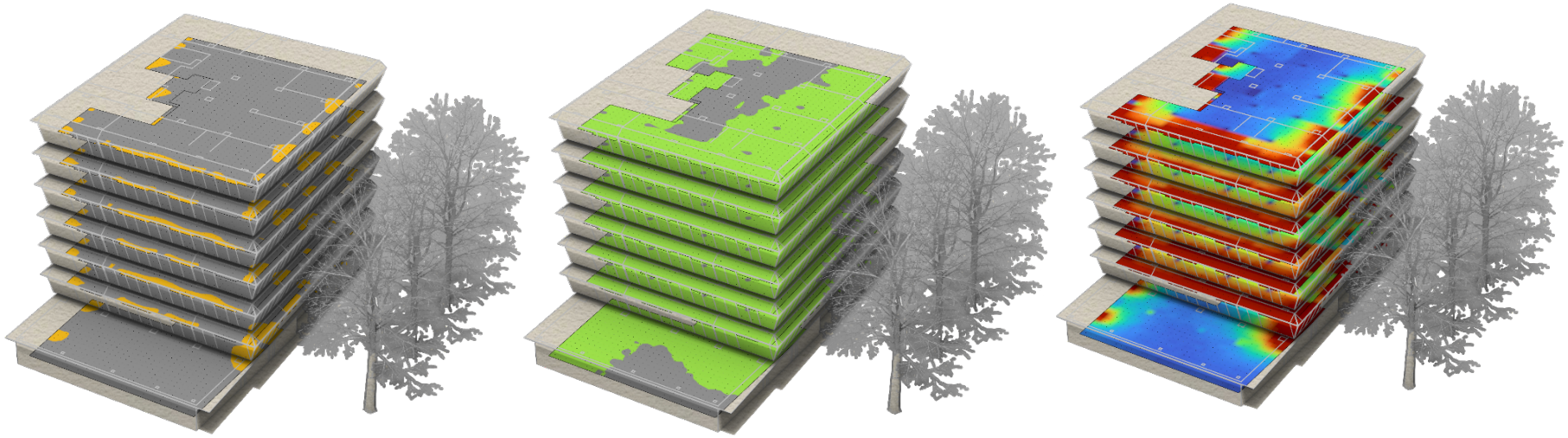
○ **Temperature thermostat:**

○ **Windows:**

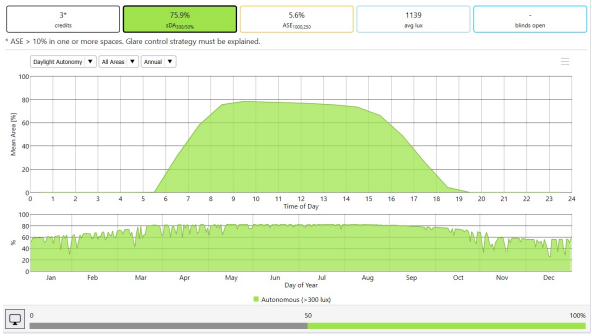
5. 8

Comfort and Environmental Quality

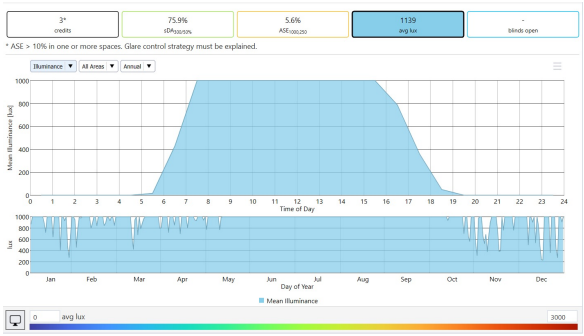
- **Daylight :**



ASE analysis



sDA analysis

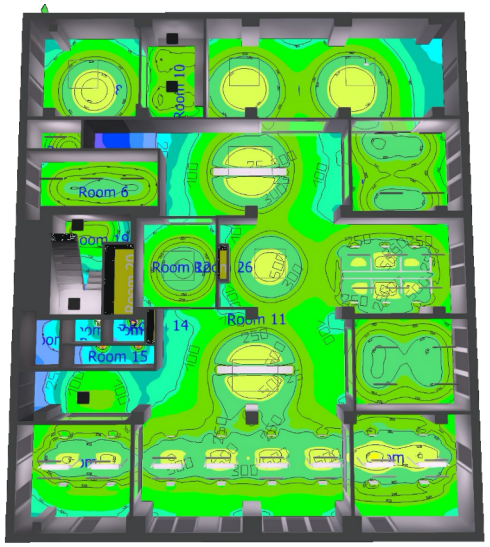


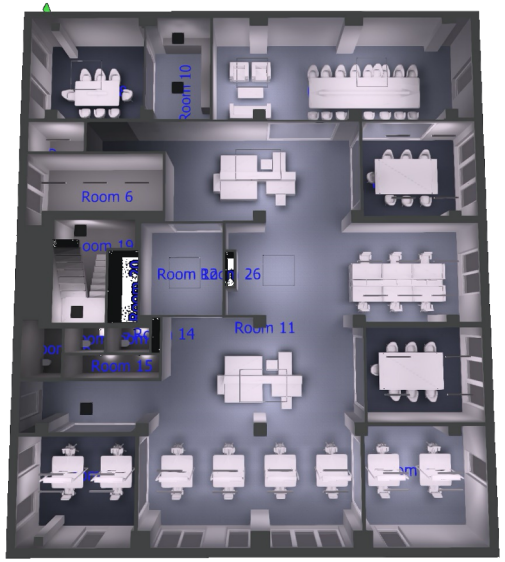
Avrg lux analysis

- **Artificial light:**

Φ_{total}	P_{total}	Luminous efficacy
171515 lm	2297.0 W	74.7 lm/W

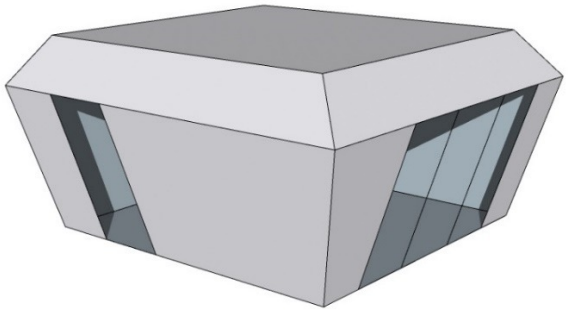
DIALux analysis



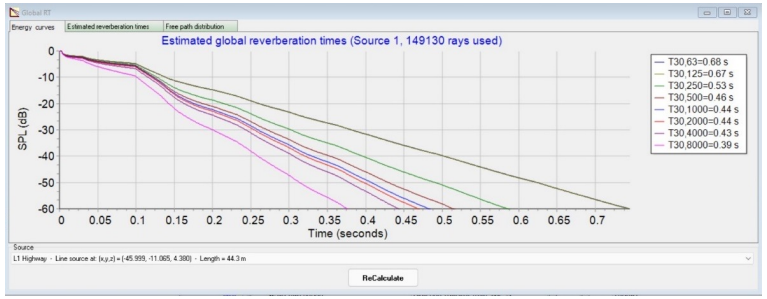


DIALux analysis

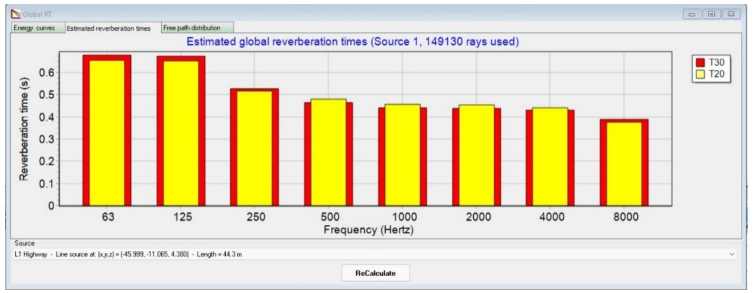
- **Acoustic:**



Sketchup model



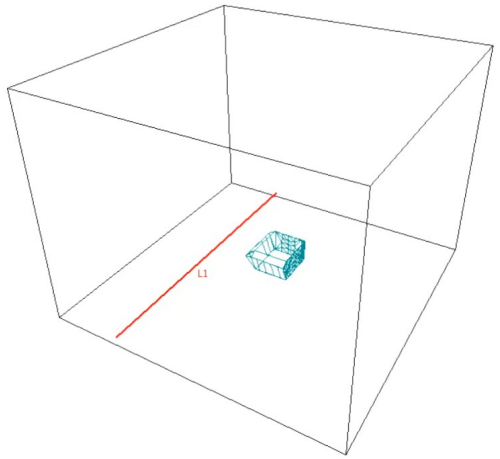
Attenuation and reverberation time function of sound



Room reverberation time function

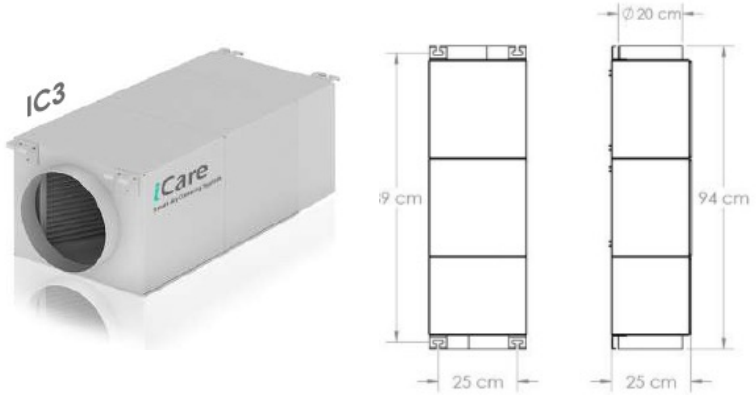
Receiver Number: 1 Room Centre								(x,y,z) = (-22.845, 1.000, 8.508)	
Band (Hz)		63	125	250	500	1000	2000	4000	8000
EDT	(s)	0.87	0.87	0.96	0.68	0.60	0.60	0.57	0.45
T(15)	(s)	0.88	0.88	0.97	0.70	0.63	0.62	0.58	0.46
T(20)	(s)	0.88	0.88	0.97	0.69	0.62	0.61	0.57	0.46
SPL	(dB)	-7.8	-7.8	-7.5	-8.8	-9.3	-9.4	-9.8	-10.5
SPL(Af)	(dB)	-34.0	-24.0	-16.1	-12.1	-9.3	-8.2	-8.8	-11.6
SPL(Direct)	(dB)	-13.1	-13.1	-13.1	-13.1	-13.1	-13.1	-13.1	-13.2

Room reverberation time function

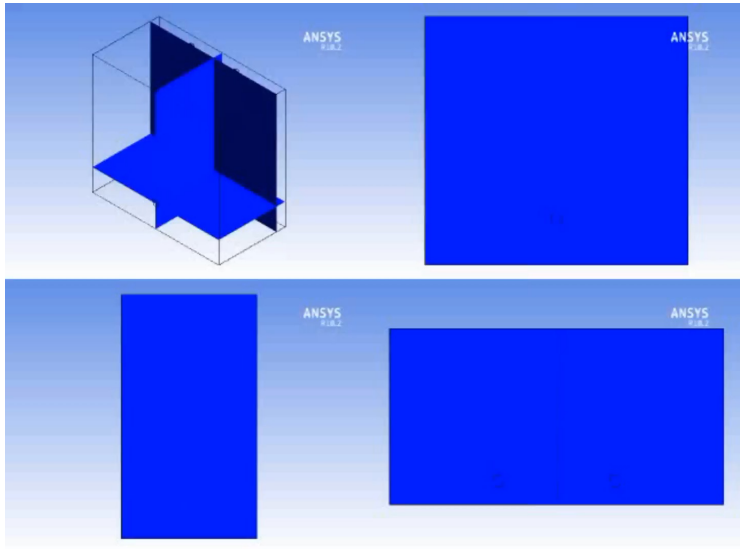


Sound simulation in glass cabin

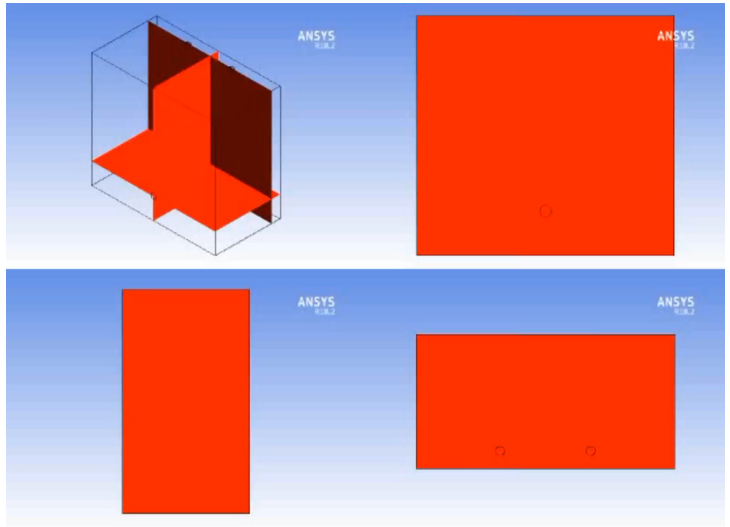
- **Ventilation**:



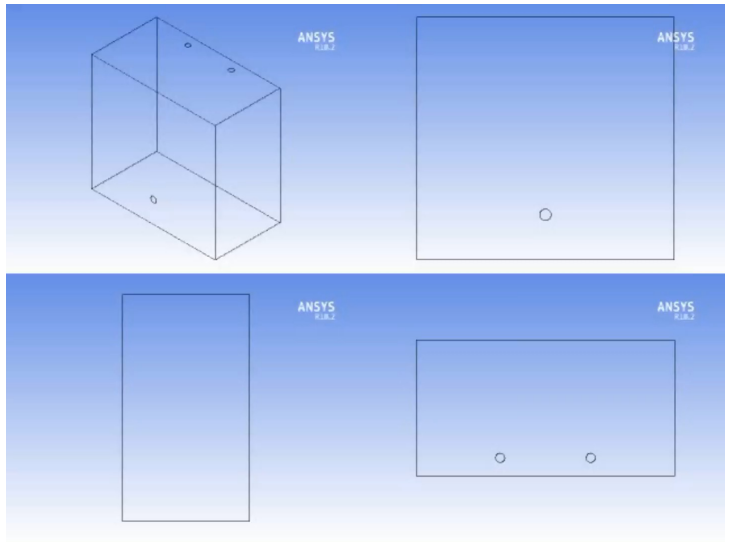
Icare filter



CFD analysis of air velocity



CFD analysis of air temperature



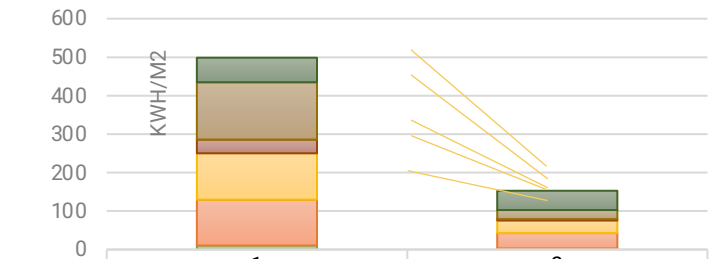
CFD analysis of air streamline

- **Using indoor green wall and plants**

Indoor plants detail

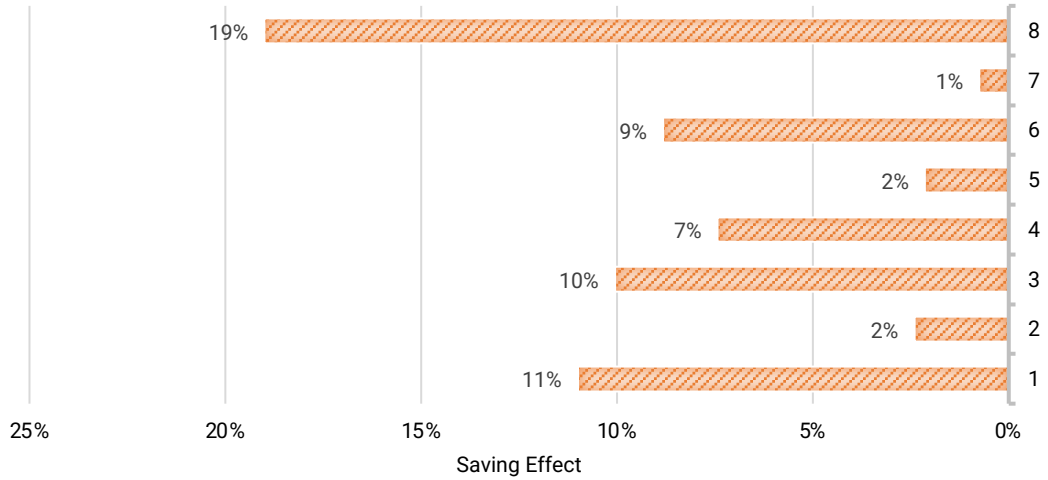
5. 9

Energy Performance

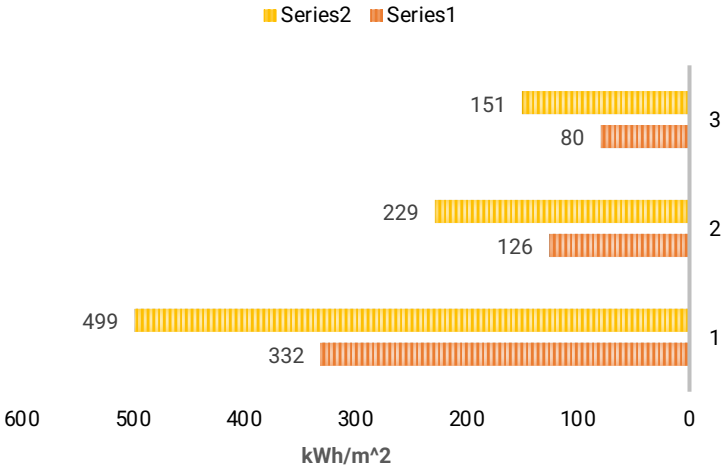


	1	2
Series6	64	50
Series5	149	24
Series4	36	4
Series3	121	33
Series2	119	40
Series1	11	3

Redesign model energy Consumption redaction respect to base model



Energy saving methods



EUI design stage

BIPVT and PVT energy generation

Solar System	Tilte (º)	Nu	EEG (kWh)	TEG (kWh)	Total (kWh)	BIPVT Generation Respect to Total Site Energy Use (%)	BIPVT Generation Respect to Total Source Energy Use (%)
Rooftop PVT	35	162	23741	51357	75098	10	7
South Façade BIPVT	35	132	19424	42019	61443	9	5
Total	-	294	43165	93376	136541	19	12

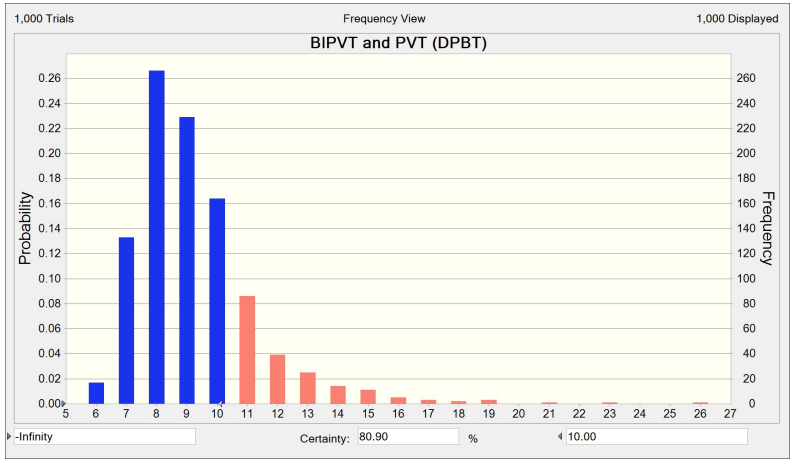
• Risk economic calculation

Risk economic calculation assumptions

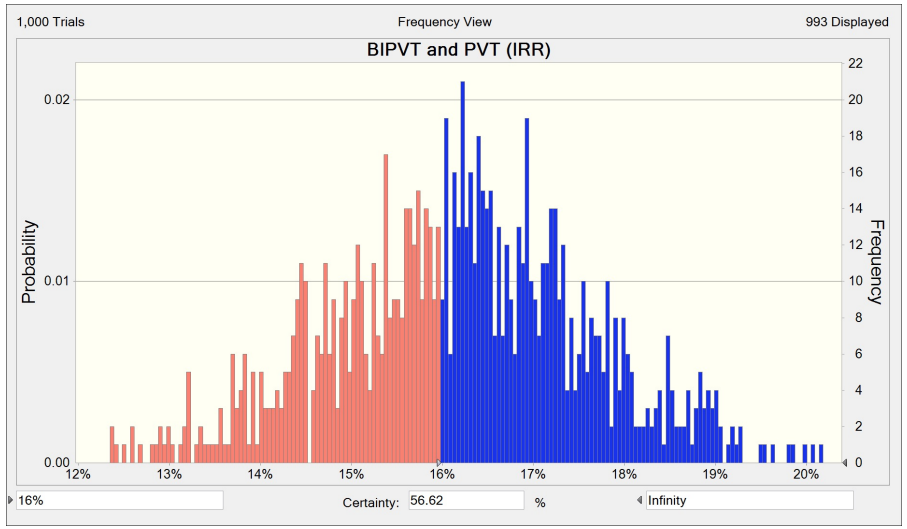
BIPVT and PVT Risk Analysis									
Initial Cost ($)	Maintenance Cost ($/year)	Conceret Foam Price ($)	Absolute Price ($)	Gas Saving (m^3)	Electricity Saving (kWh)	Gas Price ($/m^3)	Electricity Price ($/kWh)	Total Saving ($/year)	Discant Rate (%)
80734	400	3549	20184	8914	43165	0.37	0.25	14089	13

Risk economic calculation results

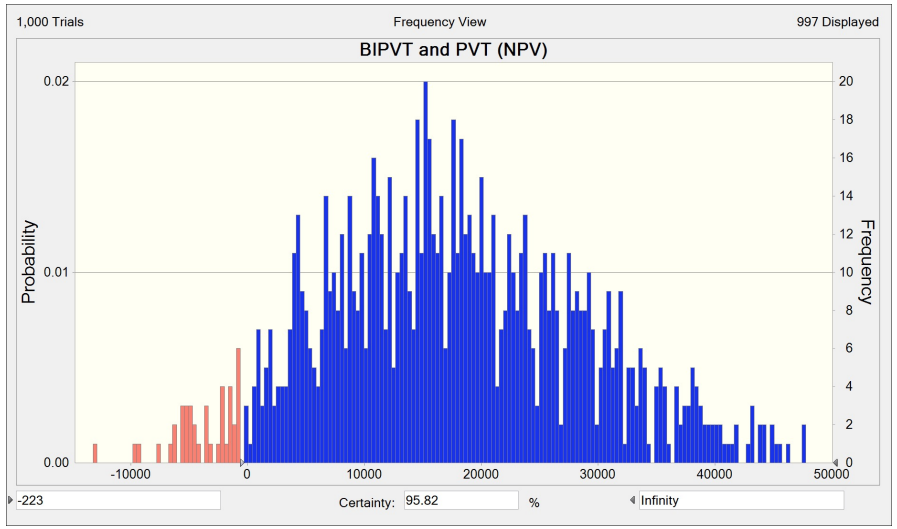
BIPVT and PVT Risk Analysis Results	Probability that the NPV will be Positive During the Life Span (%)	Probability that the IRR will be Grater than Discount Rate (%)	Probability that the DPBT will be less than 5 Years (%)
	95.84	56.62	1.21



Duration payback time



Internal rate of return



Net percent value

Industry Partnership:

Venus Glass

PUZZLE SETUP Partition

TTS

PAYEH BETON

TABAN Energy Development Co.

ASHRAE

Edge Excellence In Design For Greater Efficiencies

U.S. GREEN BUILDING COUNCIL LEED USGBC

Leca® Light Expanded Clay Aggregate

BETON MINE

THANK YOU

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