Facing the challenge of improving energy efficiency in existing buildings by Architectural Energy Retrofit (AER)

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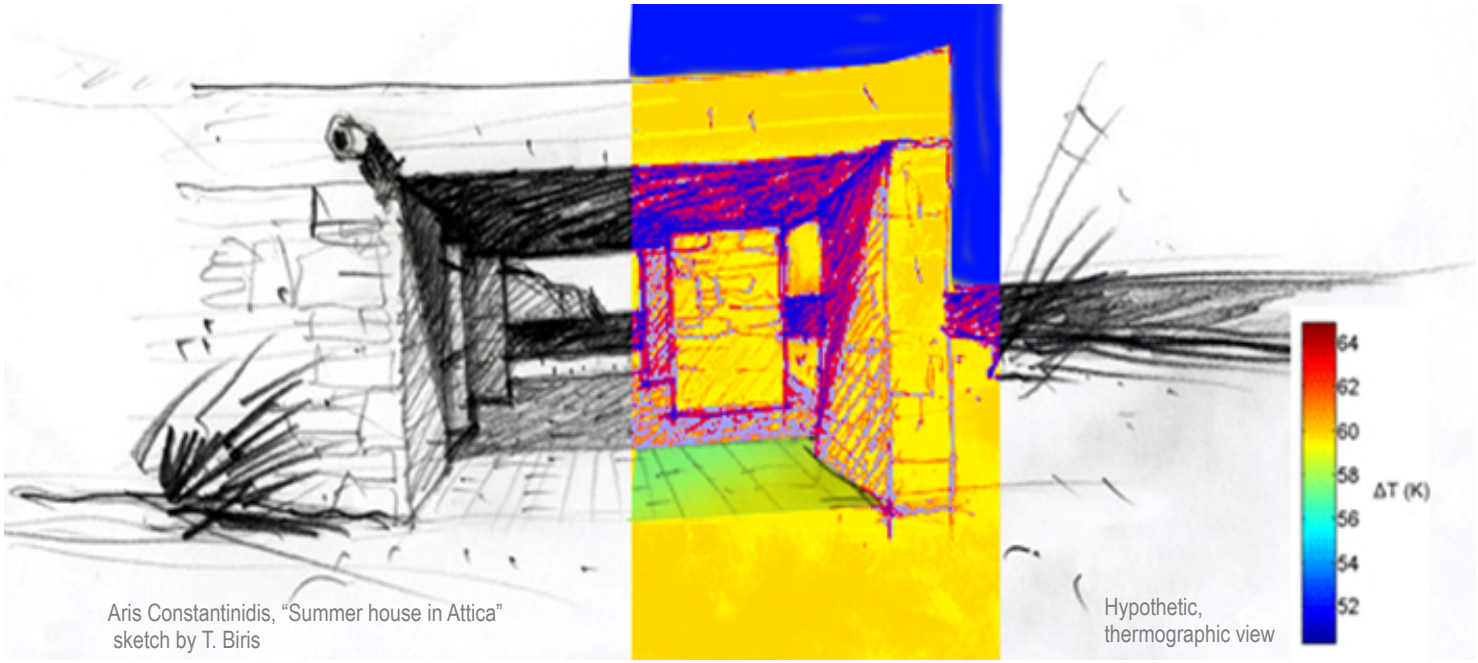
Working hypothesis

primary architectural forms of the early design phase, **predispose** the final **energy performance** of the building



Aris Constantinidis, "Summer house in Attica" sketch by T. Biris

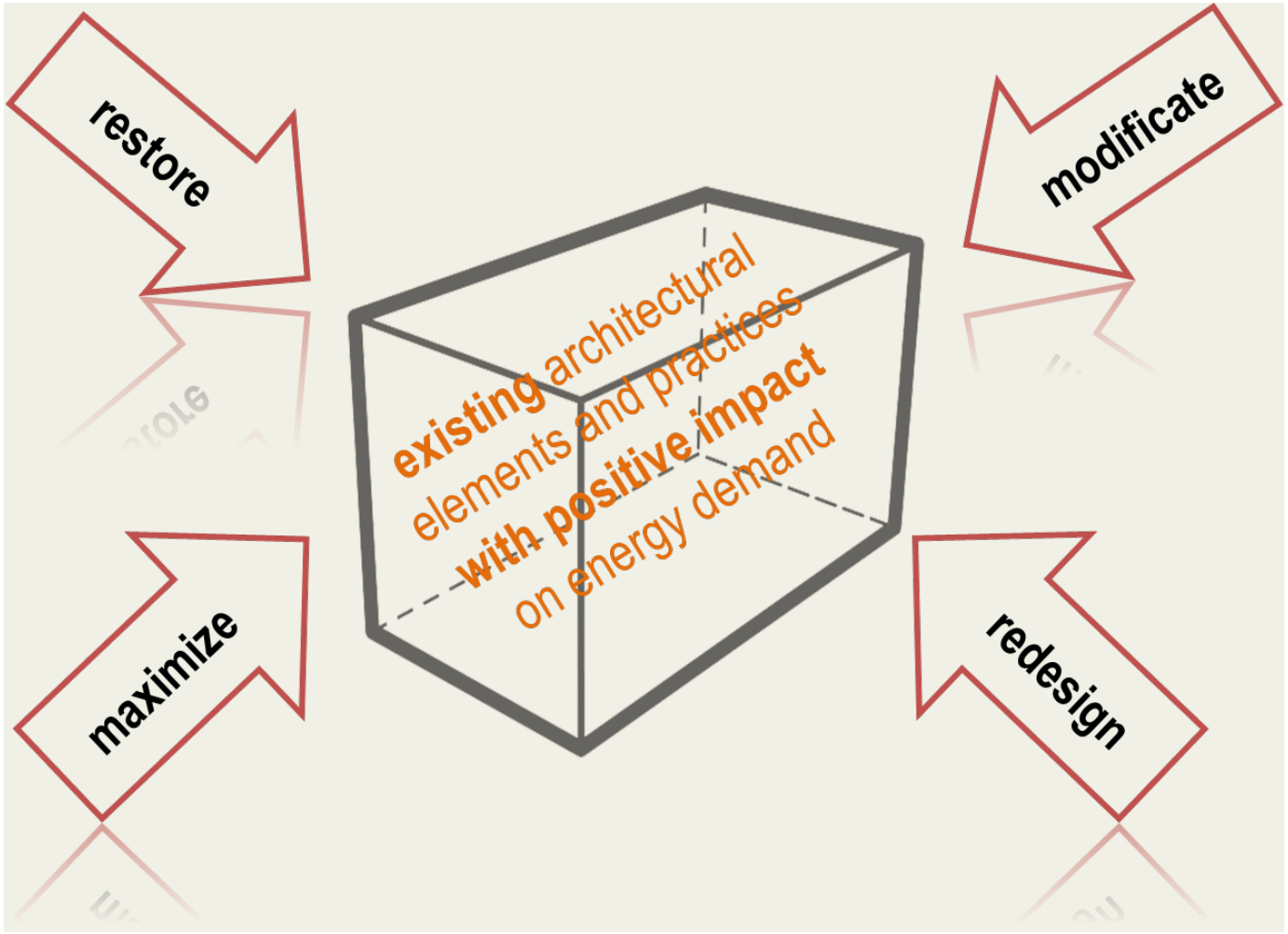
Hypothetic, thermographic view

Working hypothesis

Architectural Energy Retrofit (AER), proposes an alternative energy retrofit strategy:

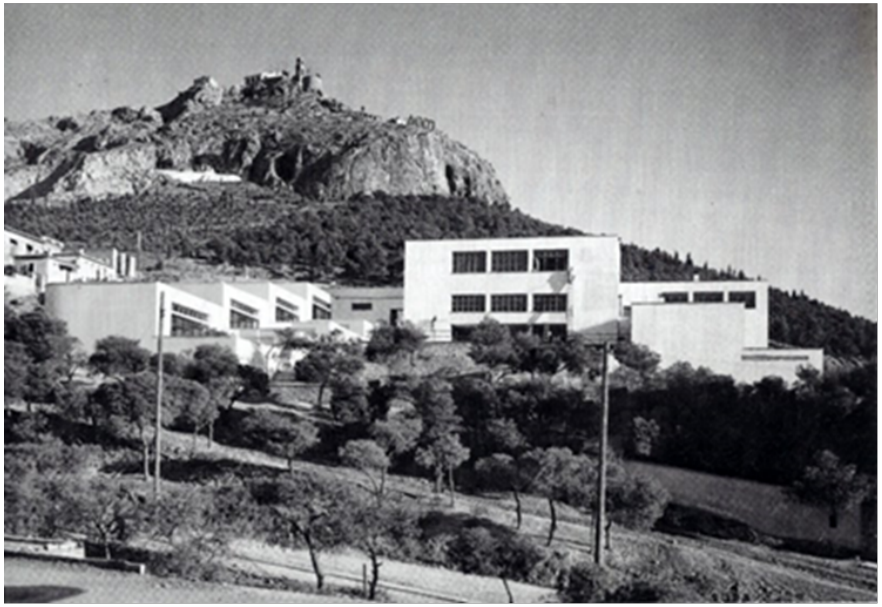
The achievement
of
substantial energy conservation
with
the implementation
of
solely architectural interventions

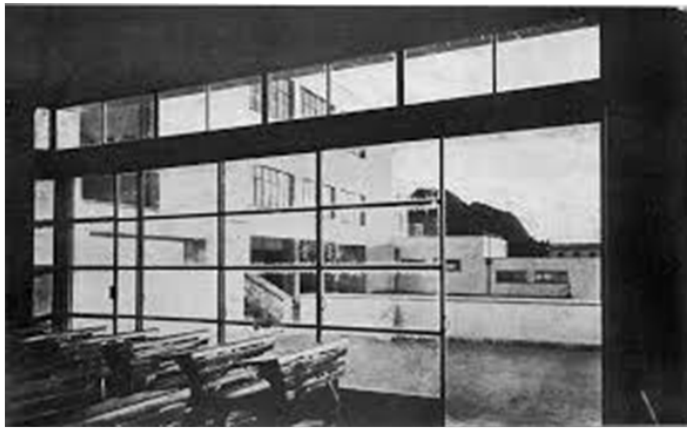
How?

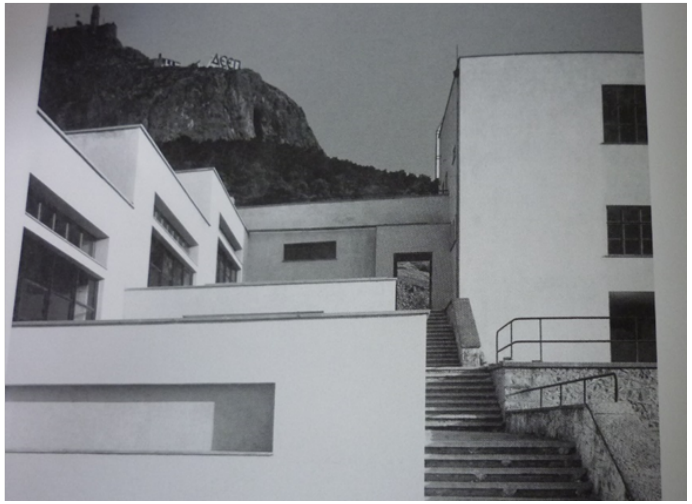

restore
modificate
existing architectural elements and practices with positive impact on energy demand
maximize
redesign

the primary school at Pefkakia in Lycabettus hill, designed by Dimitris Pikionis in 1931

The case study







Photos from "Two studies on Dimitris Pikionis",
by Antonakakis, Dimitris, 2013, *1st Edition. Athens, Domes Edition*

The case study

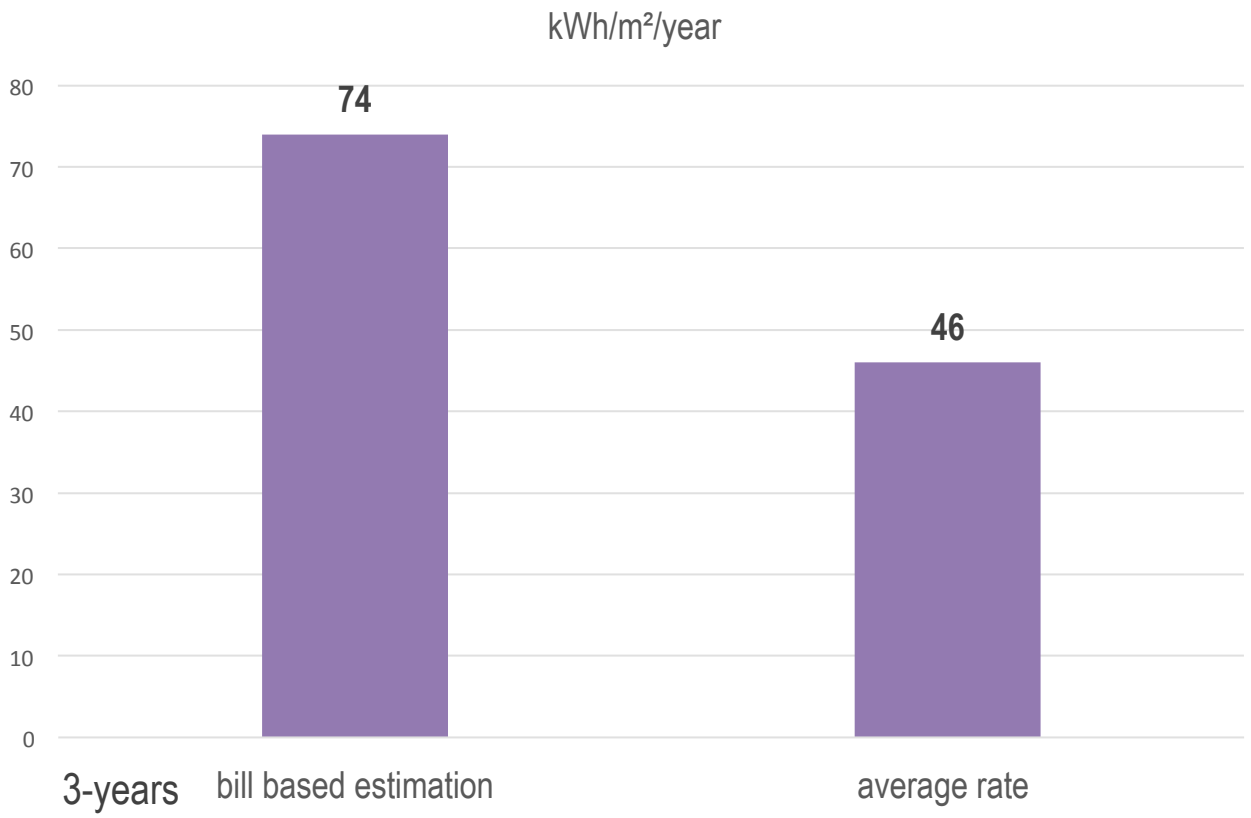
current situation

current situation

heating consumption

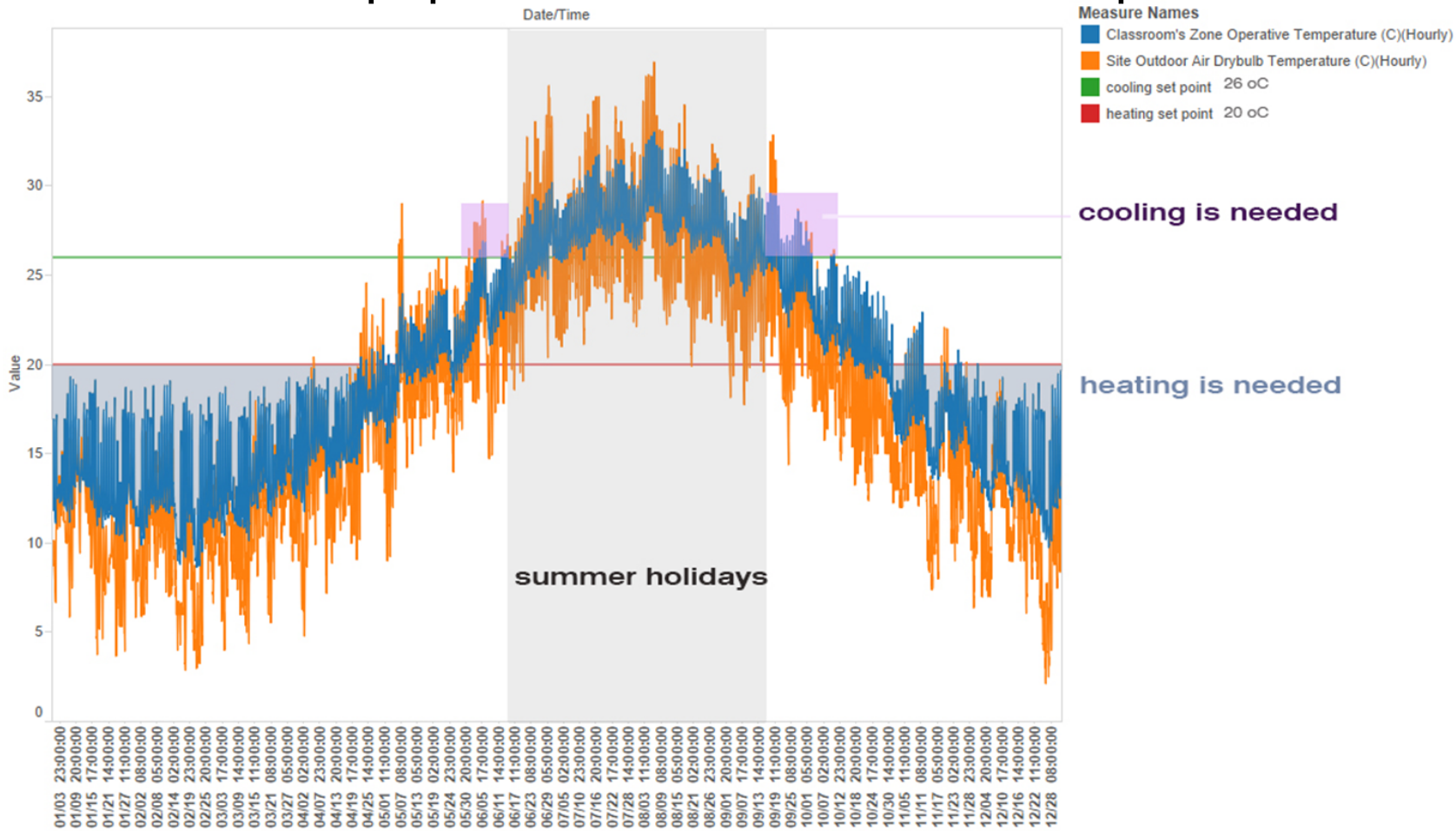
60% more energy consumption than the average
for the non insulated Greek schools of the same climatic zone *

* (Daskalaki & Sermpetzoglou, 2011)



The modelling simulation of the indoors temperature conditions in the typical classroom, verified the pupil's thermal discomfort complaints

current situation



Steps of analysis

→ **building's architectural disciplines are traced**

→ **architectural elements that affect its internal and surrounding external conditions are profiled**

→ **post-occupancy evaluation analysis of the building is performed**

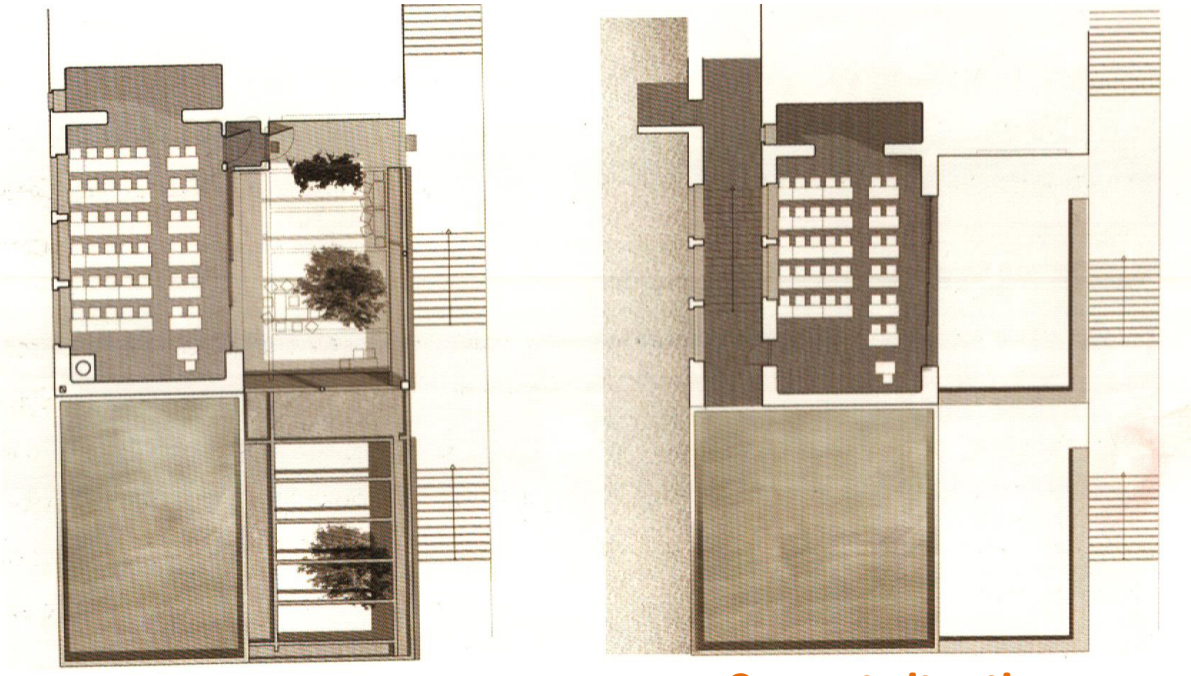
Steps of analysis

the feedback forms the basis of an energy retrofit proposal aiming at

→ minimizing building's energy demands
→ achieving the revival of the microclimatic conditions
→ non-energy benefits of of a well-designed space

original architectural concept

- human-scale classrooms and mini courtyard cluster
- flexibility and polyvalence at the open spaces
- autonomous operation



Original proposal

Current situation

Drawings from "Two studies on Dimitris Pikionis",
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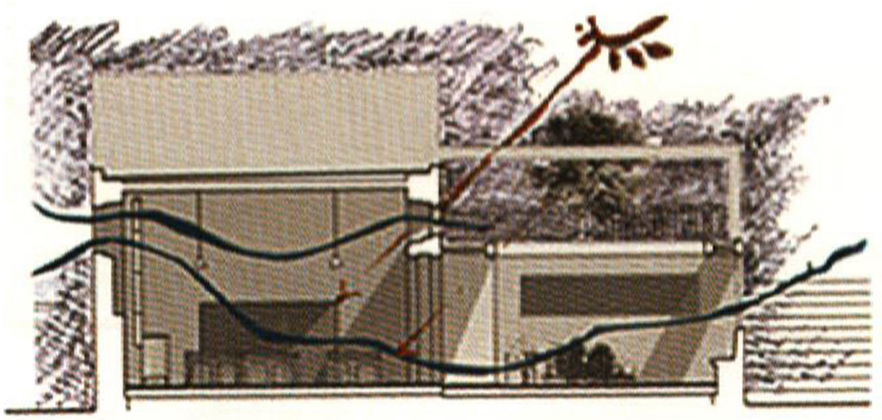
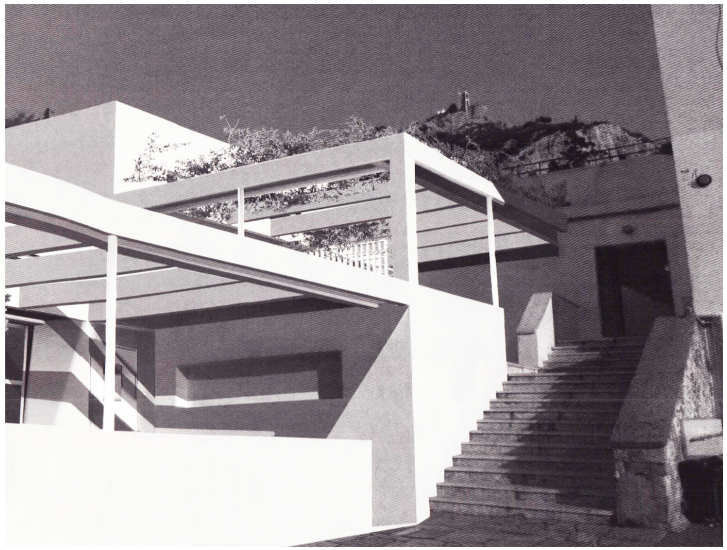
proposal





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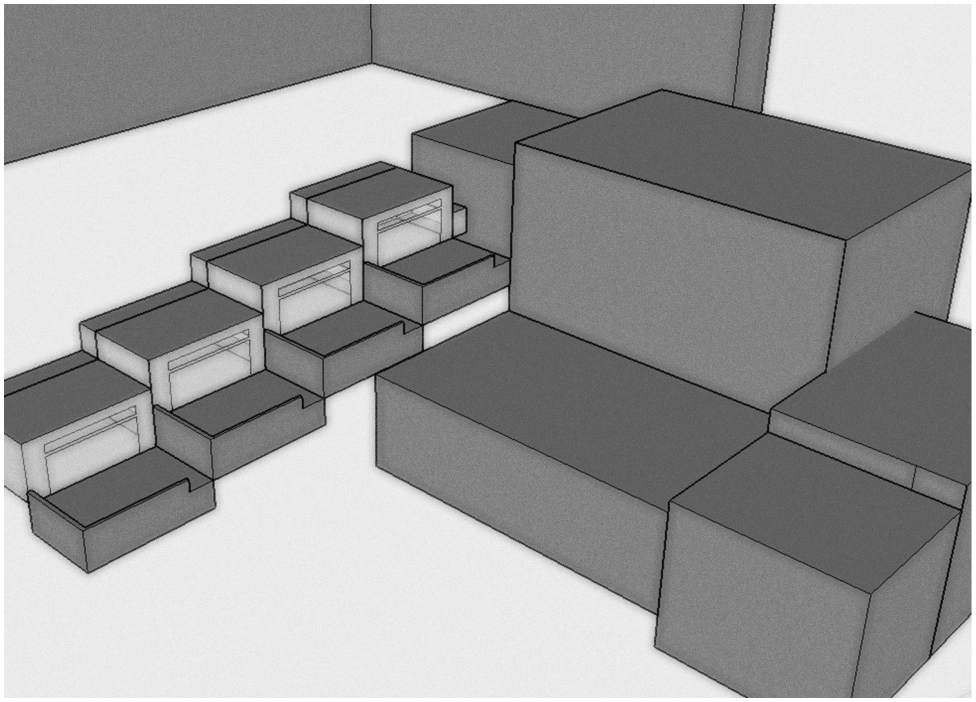
BIM modeling



EnergyPlus

AUTODESK® ECOTECT ANALYSIS

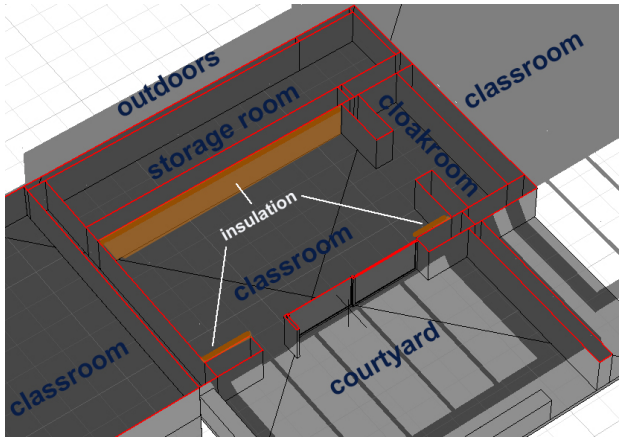
AUTODESK® SIMULATION CFD

SketchUp

ENVI-MET

tableau public

AER retrofit scenario



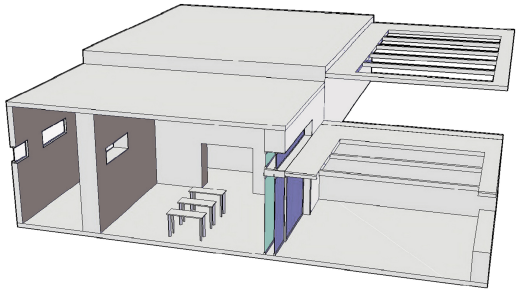
Partial thermal insulation of the masonry envelope

Table 1. Classroom's building envelope thermophysical characteristics

U values (W/m²K) *	Current Situation	Retrofit Proposal	Technical description
60cm width external plastered stone walls	2.13	0.26	10cm EPS or miner wool (conductivity=0,031W/m*K) in the internal side of the classroom
60cm width stone walls to the ground	2.28	-	no insulation
60cm width stone walls to the north storage corridor	2.13	0.2	10cm EPS or miner wool conductivity=0,031 W/m*K) in the internal side of the classroom
60cm width stone walls to the next classroom	-	-	no insulation
20cm concrete roof with 10cm lightweight concrete and wateproof asphalt membrane on the top	1	0.2	12cm EPS (conductivity=0,031 W/m*K) with light beize ceramic tiles (SR=0,58), on the existing roof
mosaic floor to the ground	3.5	3.5	no insulation

AER retrofit scenario

Openings displacement

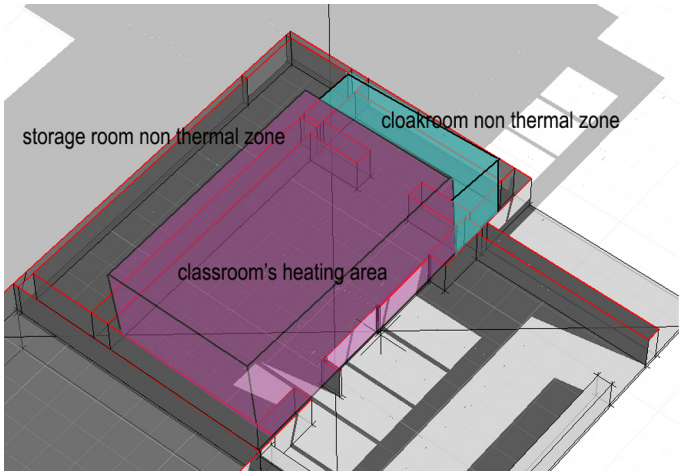


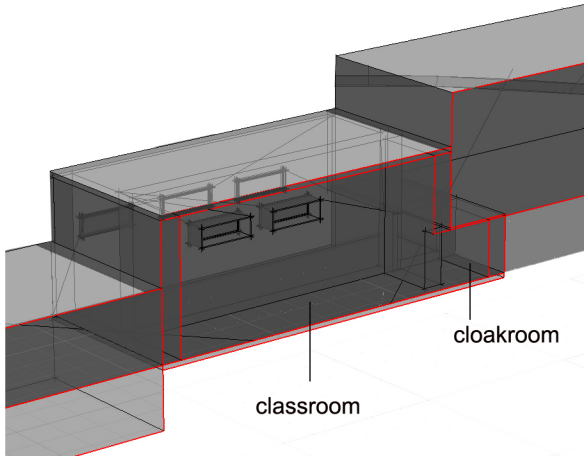
Openings	current situation (single pane frosted glass and steel frame)	retrofit scenario proposal (double pane clear glass low-e and aluminum frame with thermal brakes + current glaze façade with clear glass)
U value (W/m²*K)	6	2
Solar heat gain coefficient	0,3	0,6
Transmittance visibility	0,3	0,65

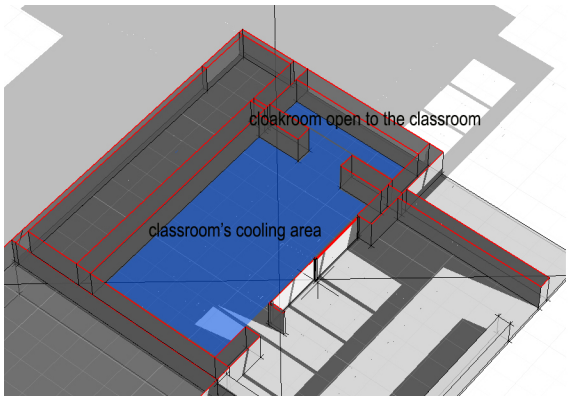
**according to the climatic zone of Athens

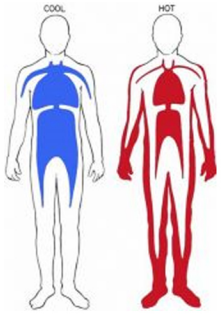
AER retrofit scenario

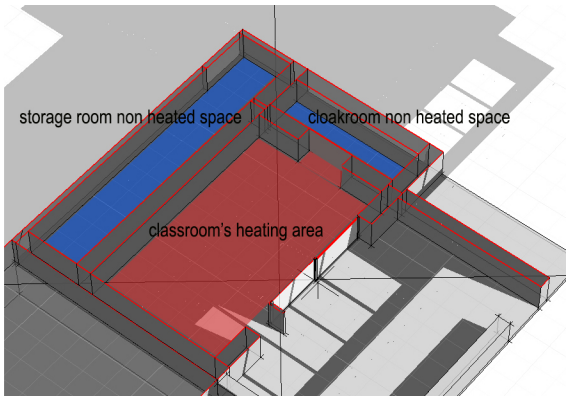
Seasonal redefining of the size and the volume of the classroom as a thermal





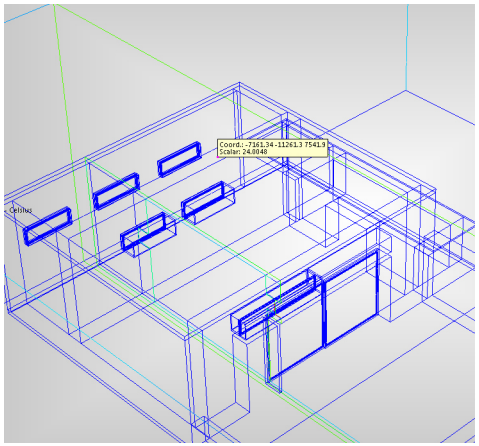


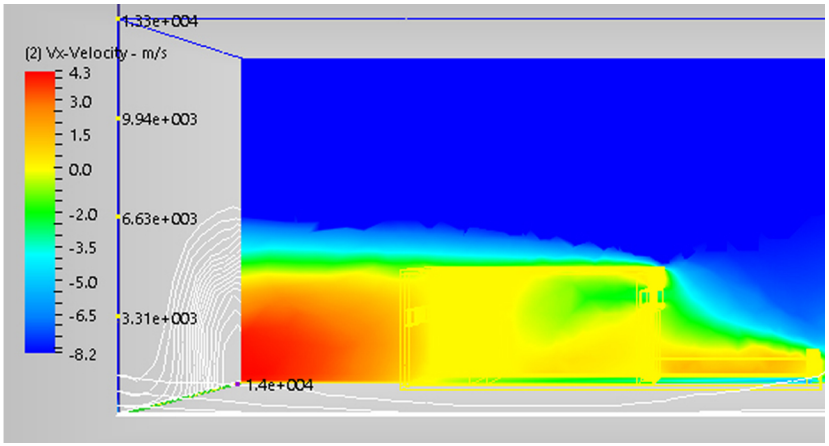


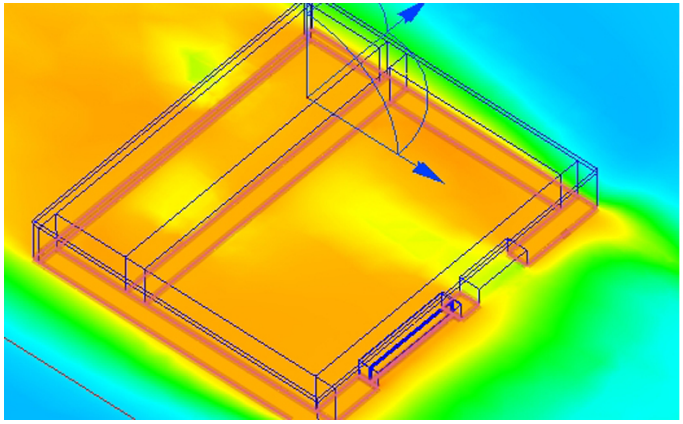


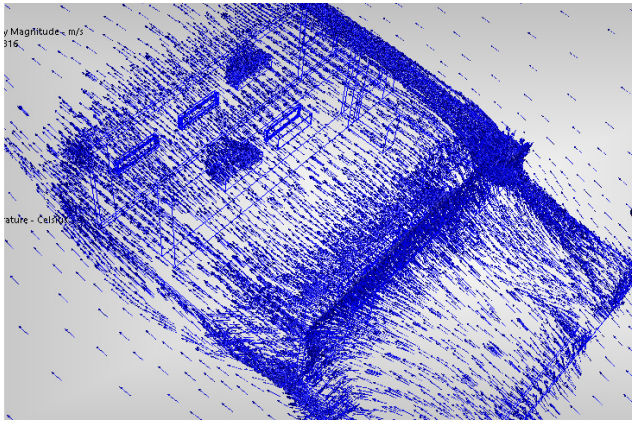
AER retrofit scenario

Natural Ventilation optimization



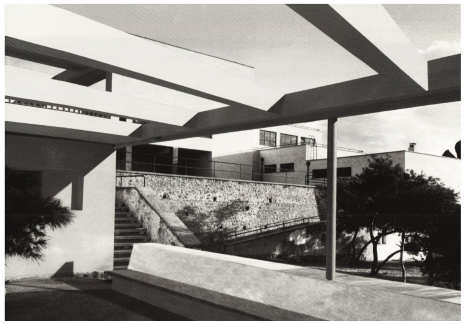
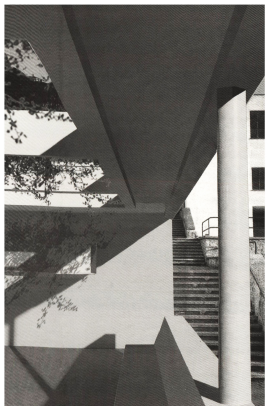






Sun shading system

AER retrofit scenario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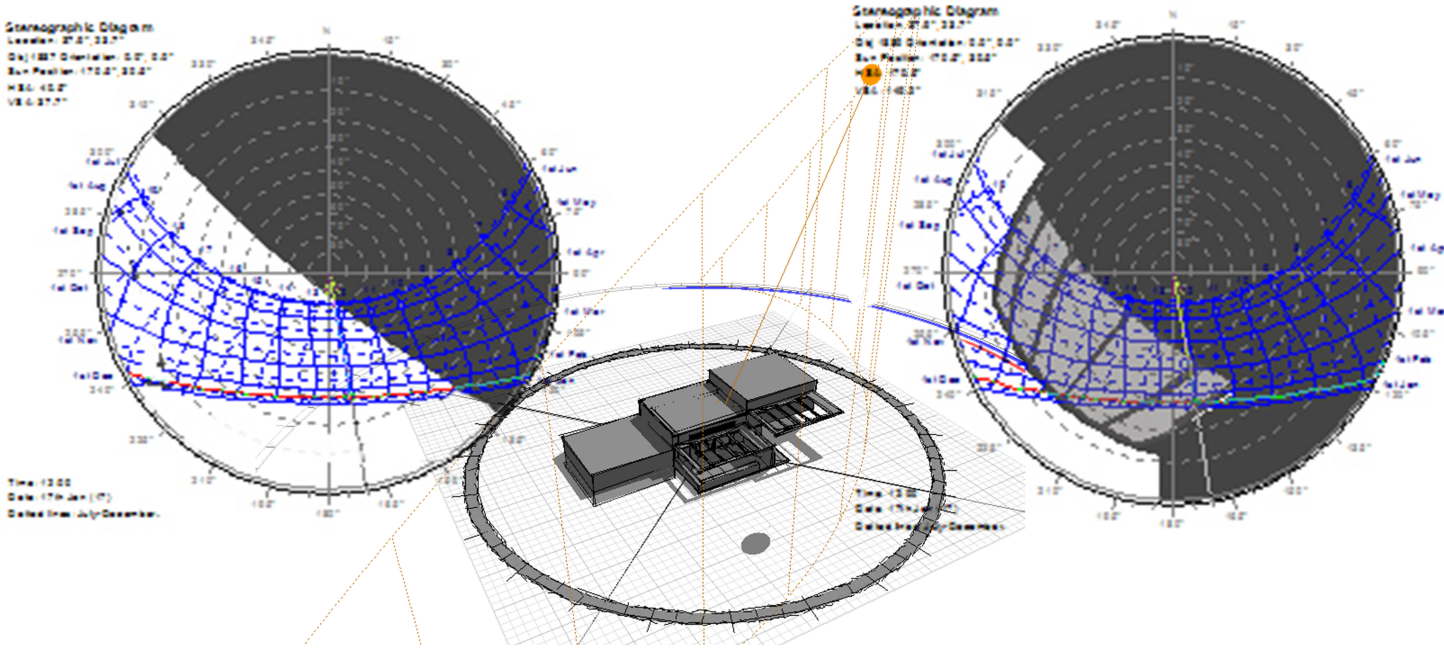
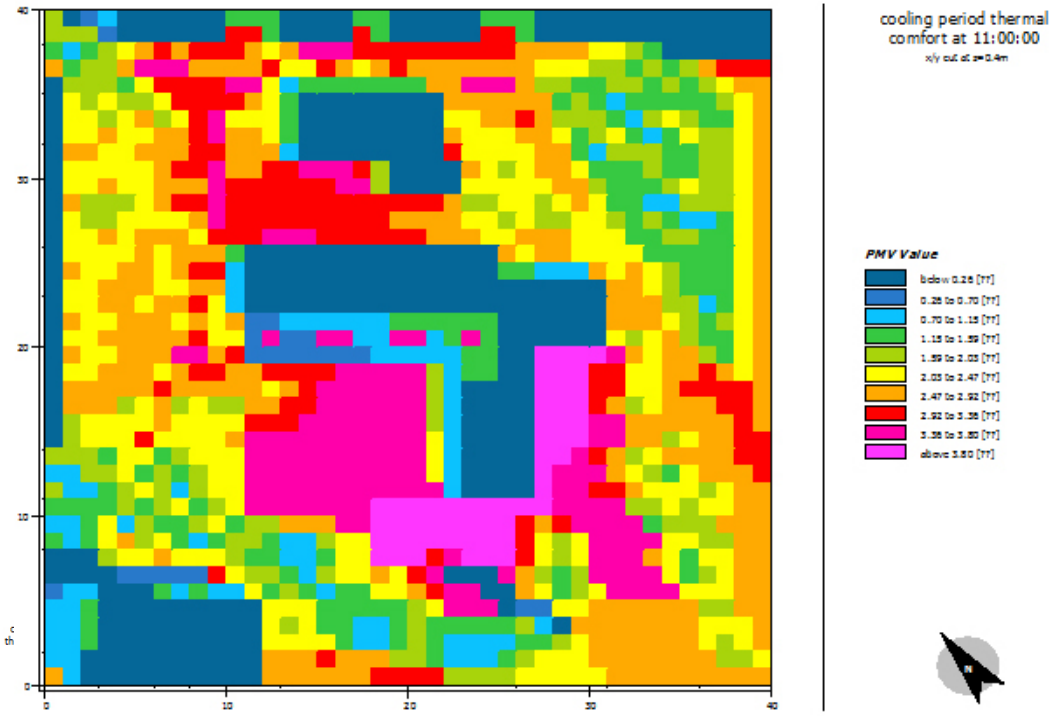
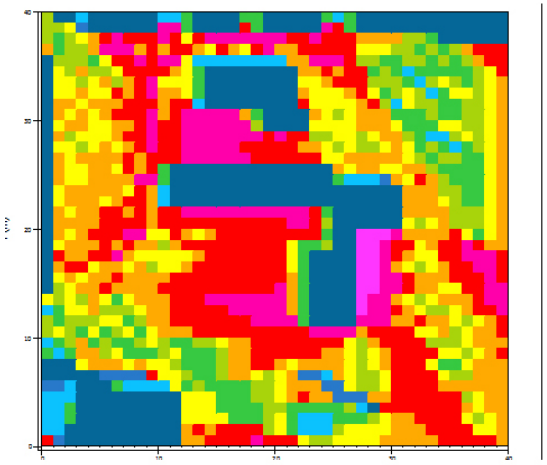


Improving the classroom's courtyard microclimate

AER retrofit scenario

After the AER, the PMV factor in the same position, was reduced in average to 1 (neutral to slightly warm), which offers satisfying conditions on the unification of indoors and outdoors scenario





Courtyard's PMV factor at the midday of June before the micro urban revitalization proposal 2.7 < PMV< 3.53 (hot),

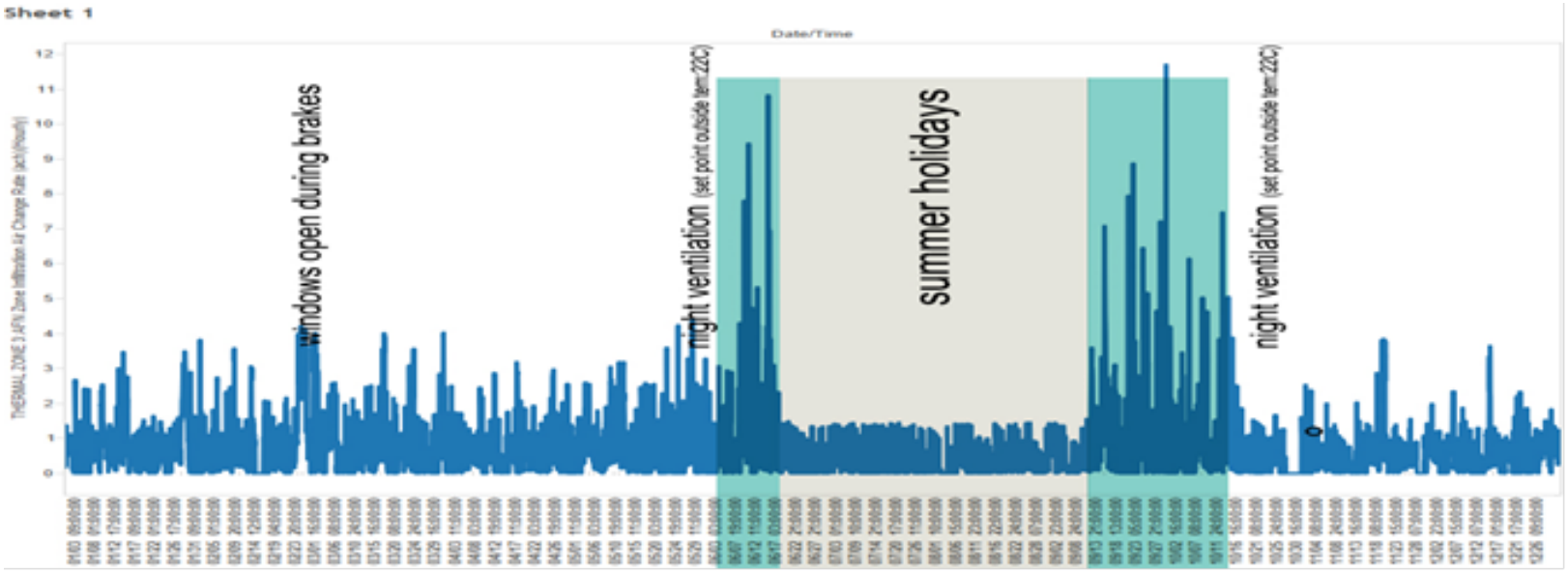
Results discussion

Table 3: Energy demands (KWh/m²) distribution and % percentage of the total energy demand reduction

	Heating	Cooling	Electicity	Total	% Demand Control
Current Situation	66.9	2.22	14.22	88.34	
Thermal Insulation Impact*	60	0.73	14.22	74.95	10.1
Openings* Displacement	49.7	0.76	14.22	64.68	22.4
Sun Shading System*	50.23	0.66	14.22	65.11	21.9
Nat. Vent. Control *	36.8	0.26	14.22	51.28	38.5
Daylighting optimization*	43.65	0.26	2.73	46.48	**44.2**

The results show nearly a 45% reduction of energy demands, paving the way for nearly zero energy final performance.

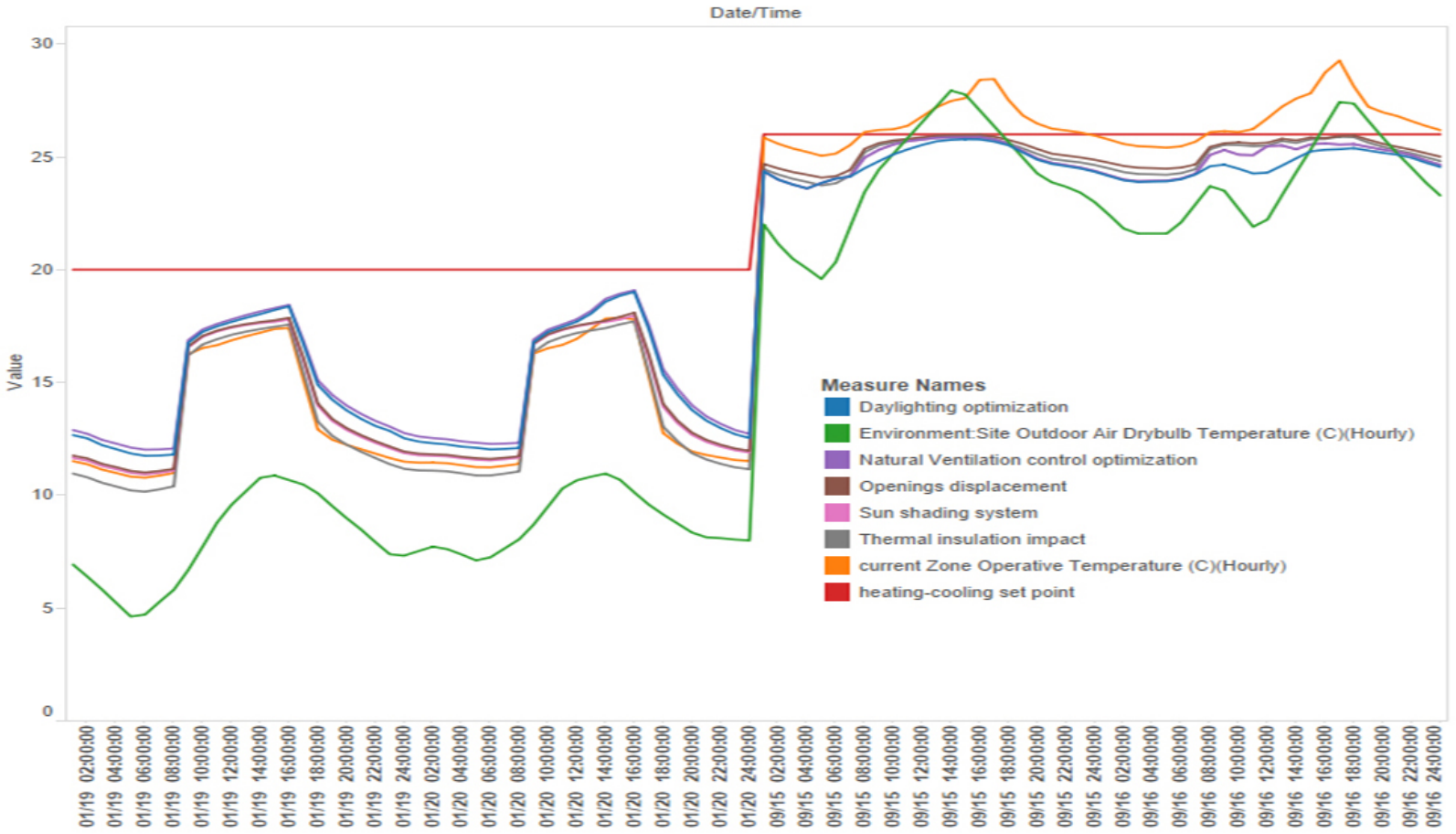
Results discussion



- Sufficient natural ventilation (2-3 ACH) during winter courses with moderate use cross ventilation rates for cooling from end of May until start of October.

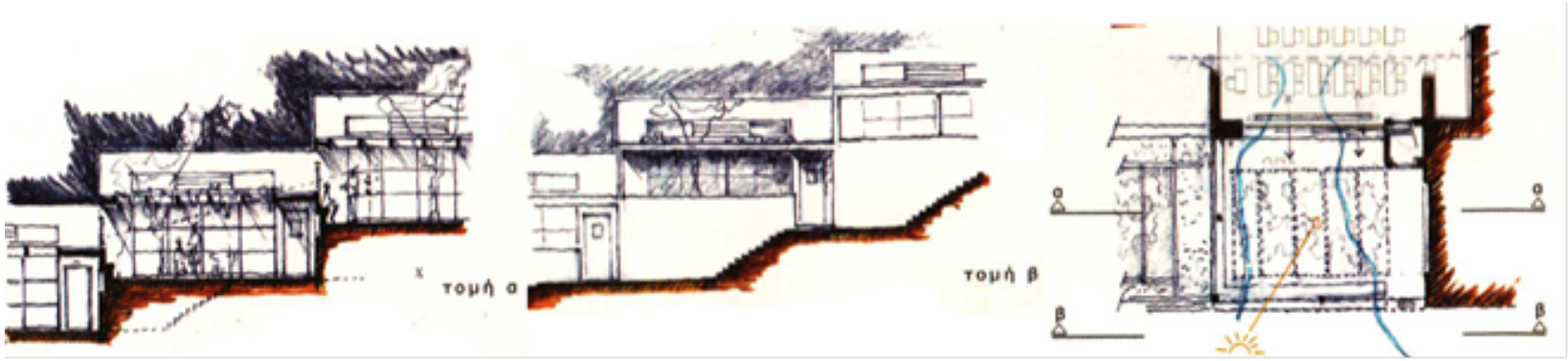
- The combination of night ventilation for precooling the high thermal capacity envelope and cross ventilation during the day, can limit drastically the need for cooling system.

Results discussion



● During the heating period, the set of the AER measures further increase the indoors operative temperature 1, 5 – 2o C in average. During the cooling period the indoors operative temperature is lower 2- 2,5 o C than the current conditions.

Results discussion



●Non-Energy Benefits

Educational related benefits,
good IAQ,
health and well-being,
lower operating cost,
flexibility in use, space enhancement,
increase of functionality,
stimulative environment

conclusions

- Maximizing user's and space's options to adjust to different seasonally environmental conditions will lead evidently to the optimum operation of the designed space and to the best response of the end-user's energy behavior.

- Necessary condition of the above working hypothesis is the architect to keep up with the perpetual progress in the energy design and management arena that influences dramatically the built environment.

- Long term potential paybacks from minimizing maintenance and upgrading building services systems and achieving better adjustment to future climate, building's use and operational changes should be further studied in order to balance the high risk factor of the applied bioclimatic strategies.

conclusions

By developing mechanisms and symbiotic strategies based on the restoration of architectural qualities, the building "opens" at its surrounding environment instead of being "sealed".

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