jOiNEd For sUsTainability - bUilding climate REsilient communities in WB and EU

Energy efficiency improvement measures for renovation of modernist buildings heritage

Liljana D. Sofronievska,
Faculty of Architecture,
Ss. Cyril and Methodius University, Skopje

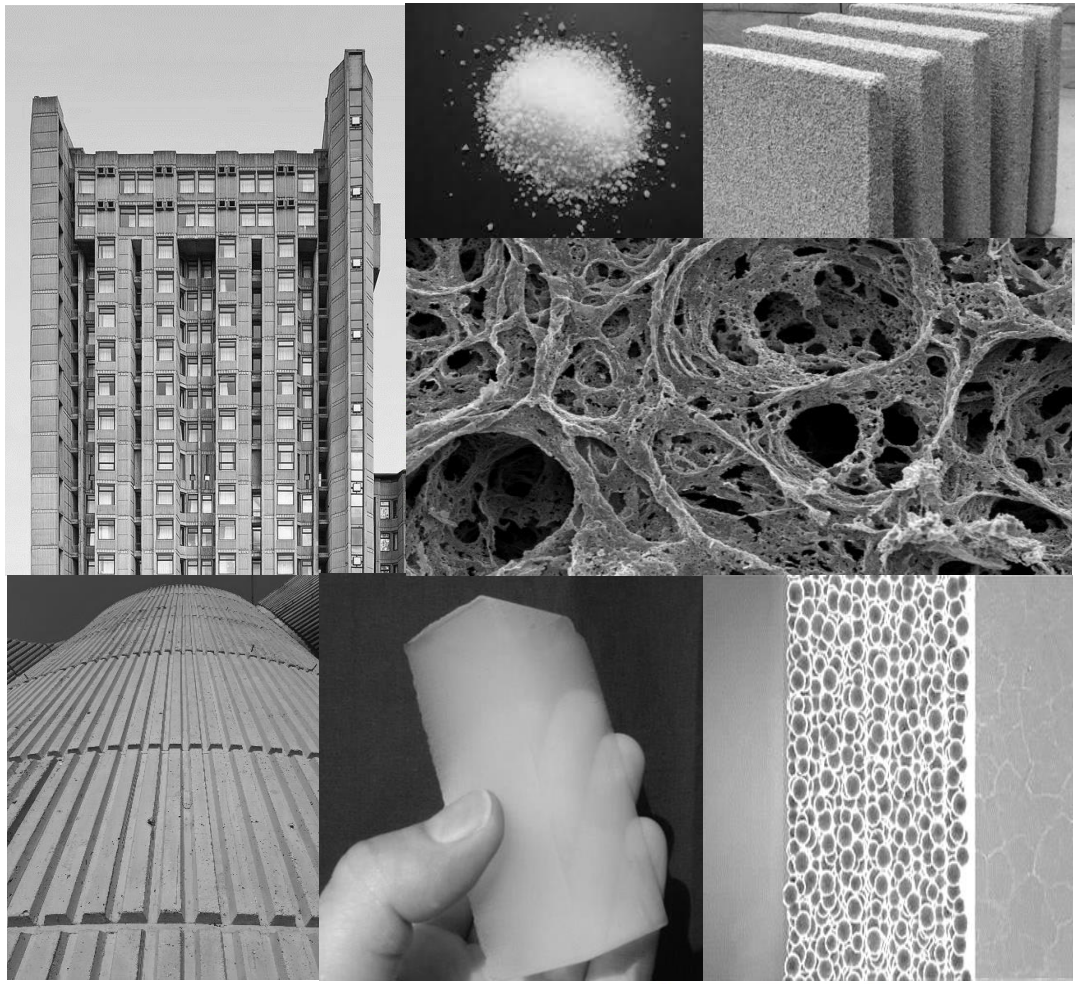
03.07.2024
Ohrid

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EACEA. Neither the European Union nor the granting authority can be held responsible for them."

1. DEFINING THE PROBLEMS, OBJECTIVES AND GOALS:

- Modernist cultural heritage
- Energy efficiency
- Sustainability
- CO_2 emissions
- Circular economy
- Building information modeling
- Building renovation
- Life cycle and costs



Co-funded by the European Union

2. CULTURAL HERITAGE FROM THE MODERNIST PERIOD IN SKOPJE:

Co-funded by the European Union

3. IMPORTANT MODERNIST BUILDINGS THAT NEED ENERGY EFFICIENT RENOVATION:

Modernist buildings from in the post - earthquake period in Skopje

Co-funded by the European Union

3. IMPORTANT MODERNIST BUILDINGS THAT NEED ENERGY EFFICIENT RENOVATION:

3.1. Detecting the most vulnerable category of modernist buildings

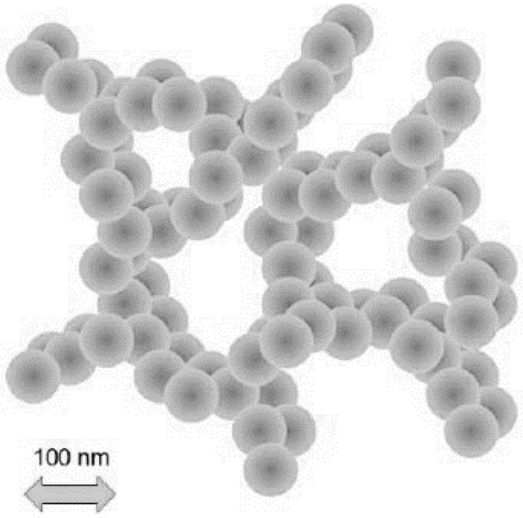
Key problems with "brutalist" buildings:

- High coefficient of thermal conductivity λ W/(Km)
- High thermal mass
- Exposure and vulnerability to external influences
- Losing authenticity by isolating the envelope
- Disadvantages in insulating the buildings from the inside
- Specific architectural facade design
- Large representation of natural concrete buildings

Co-funded by the European Union

4. NANOMATERIALS SELECTION AND PROPERTIES:

4.1. Aerogel thermal insulating plaster



Nano porous structure of aerogel thermal insulation material

Silica aerogel based thermal mortar – methods of façade wall application

Thermal properties of silica aerogel thermal plaster

Aerogel based thermal insulation plaster thermal properties	
λ (W/mK)	0.028
c (J/kgK)	990
ρ (kg/m³)	220
d (m)	0.06
μ [-]	4-5

High thermal insulation, nanoporous, low thickness, vapor permeable, non toxic, circular material, mineral composition, easy application, waterproof, fireproof, acoustic, reproduction of historical buildings

Co-funded by the European Union

4. NANOMATERIALS SELECTION AND PROPERTIES:

4.1. Aerogel thermal insulating plaster

Renovation of a historical building façade with aerogel thermal plaster

Natural concrete façade“beton–brut”

Façade material (aerogel plaster) with concrete texture

Criteria for cultural heritage building’s renovation:

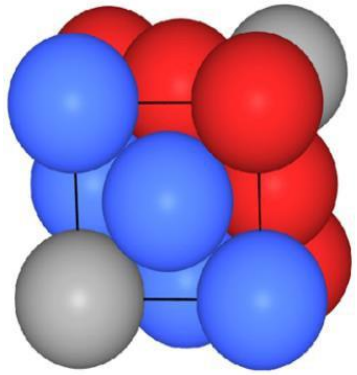
- ✓ Authenticy
- ✓ Integrity
- ✓ Reversibility
- ✓ Compatibility

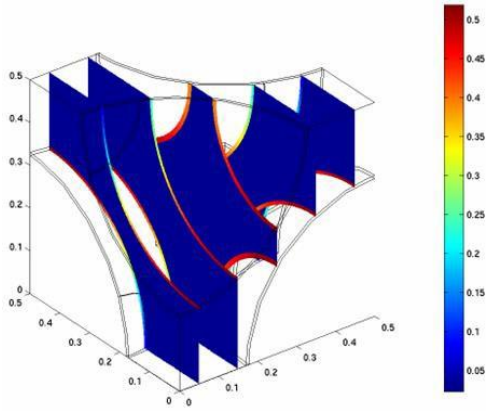
Aerogel thermal plaster is a very promising material for modernist heritage renovation

Co-funded by the European Union

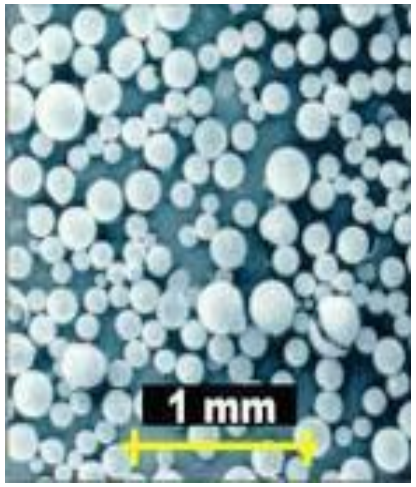
4. NANOMATERIALS SELECTION AND PROPERTIES:

4.2. Nano ceramic thermal insulating coating





Model of the nano structure of ceramic spheres in the nano coatng façade material



Nano size of spheres

Deformations of different facades a) facade coated with conventional paint; b) facade coated with nanocoating

Criteria for cultural heritage building's renovation:

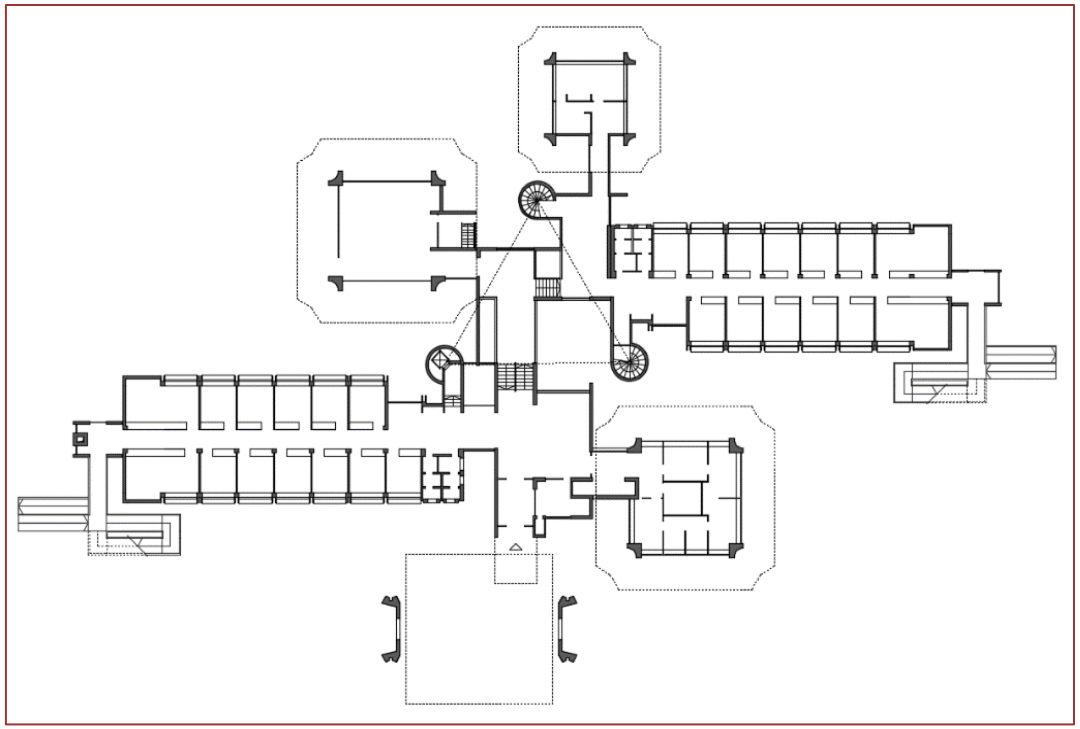
- ✓ Authenticy
- ✓ Integrity
- ✓ Reversibility
- ✓ Compatibility

Promising material with high thermal insulation, high solar reflectance, nano porous, transparent, very low thickness, vapor permeable, non toxic to environment, easy application, circular material

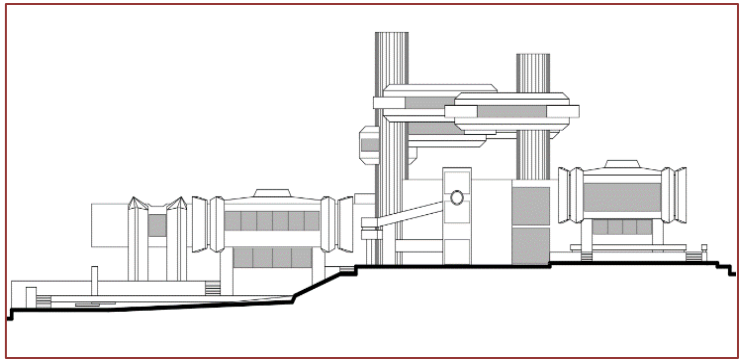
Co-funded by the European Union

5. ENERGY PERFORMANCE SIMULATIONS BEFORE AND AFTER NANOMATERIALS APPLICATION:

5.1. Case study building - description



Ground floor plan

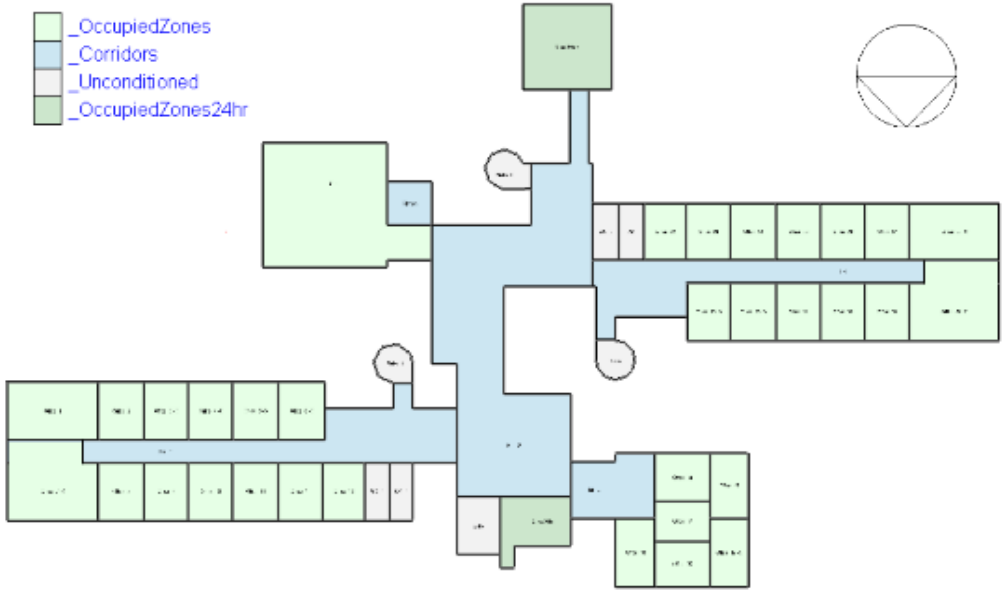


Facade

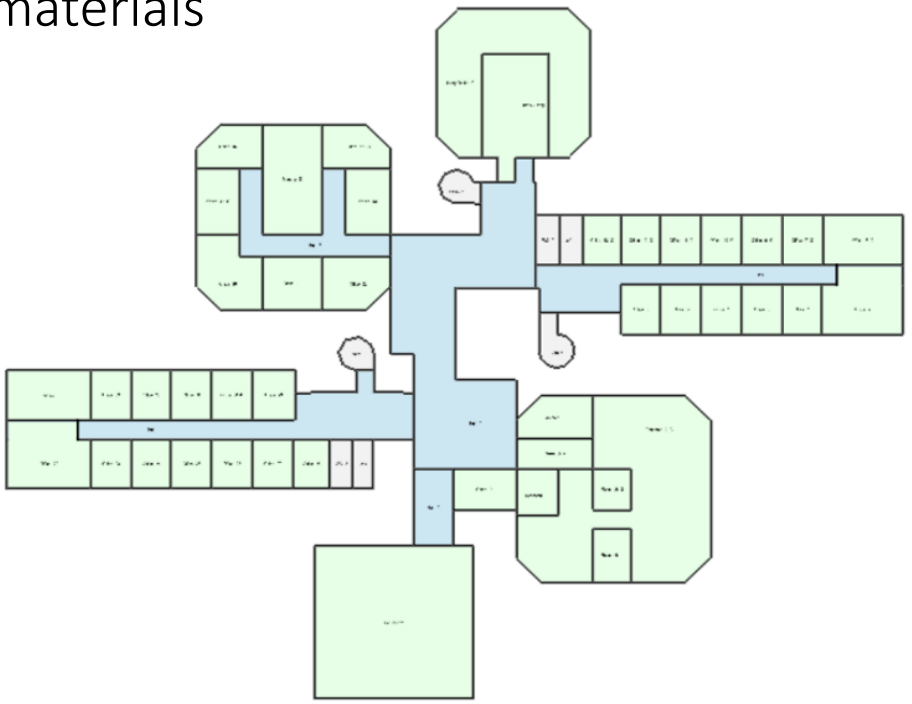
Co-funded by the European Union

5. ENERGY PERFORMANCE SIMULATIONS BEFORE AND AFTER NANOMATERIALS APPLICATION:

5.2. Case study building – Modeling, zoning, geometry, materials



Case study building ground floor zoning



Case study building first floor zoning

Zones summary

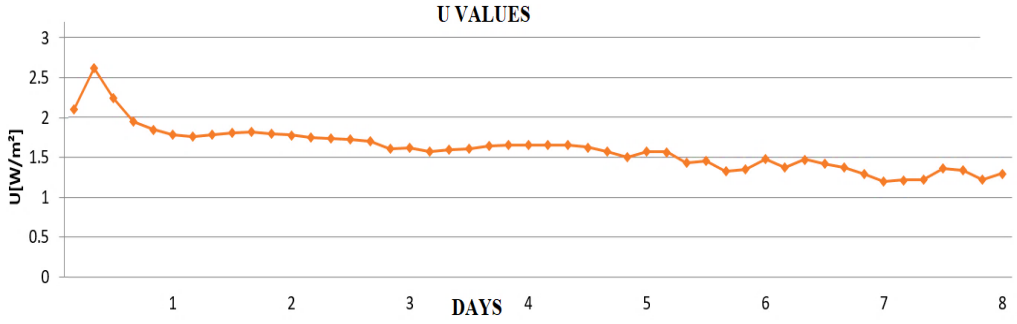
Zones summary	Area [m^2]	Volume [m^3]	Above Ground Gross Wall Area [m^2]	Underground Gross Wall Area [m^2]	Window Glass Area [m^2]	Total Openings Area [m^2]
Total conditioned area (m^2)	2647	8085	2468	9.6	658	712
Total unconditioned area (m^2)	694	2103	694	325	43	49

Co-funded by the European Union

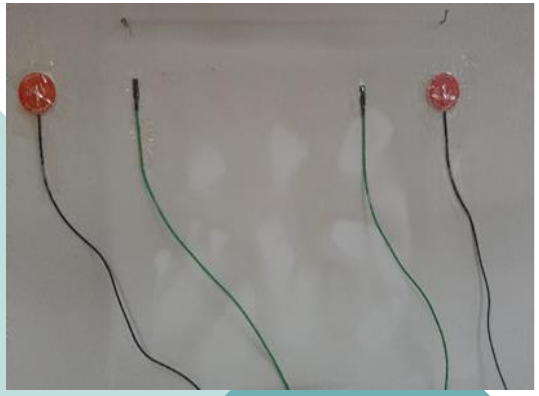
5. ENERGY PERFORMANCE SIMULATIONS BEFORE AND AFTER NANOMATERIALS APPLICATION:

5.3. Case study building – In situ U coefficient wall measures

Measuring equipment with data logger - TRSYS01 – HFM

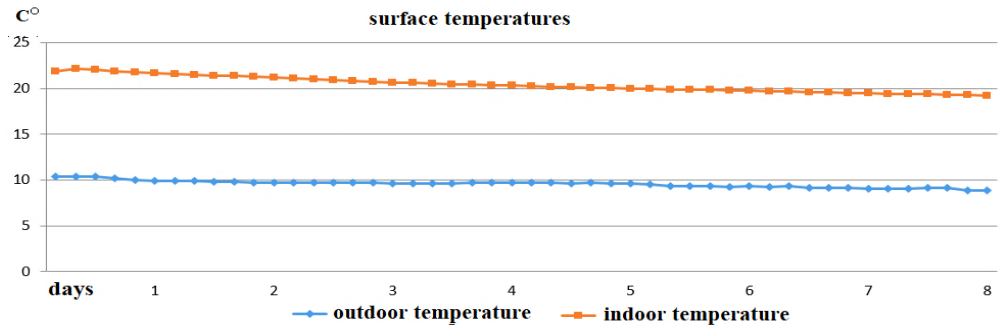


Average U values during the measurement period



Inside heat flux measurements

Outside heat flux measurements

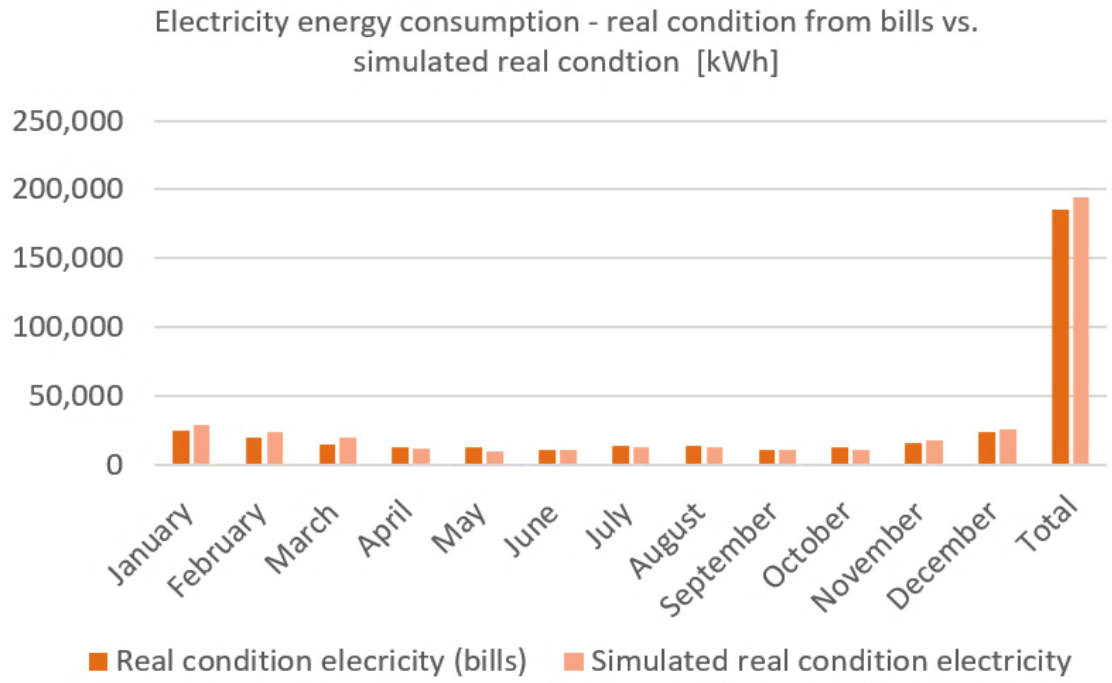


Average values of wall **surface** temperatures during the measurement period

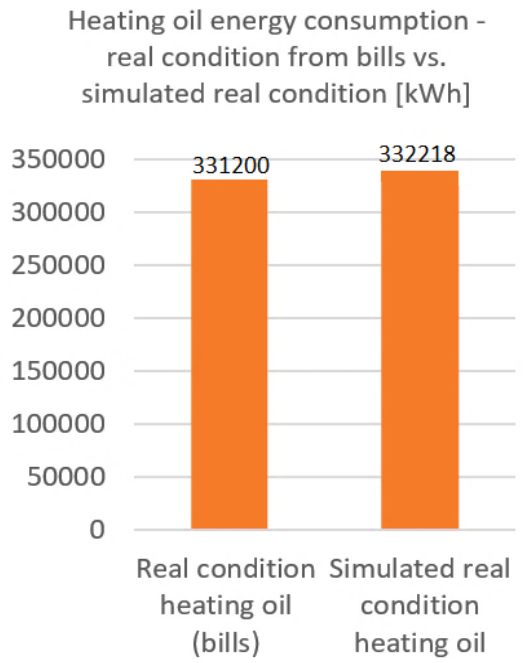
Co-funded by the European Union

5. ENERGY PERFORMANCE SIMULATIONS BEFORE AND AFTER NANOMATERIALS APPLICATION:

5.4. Energy simulation results



Electricity consumption (bills vs. simulation)

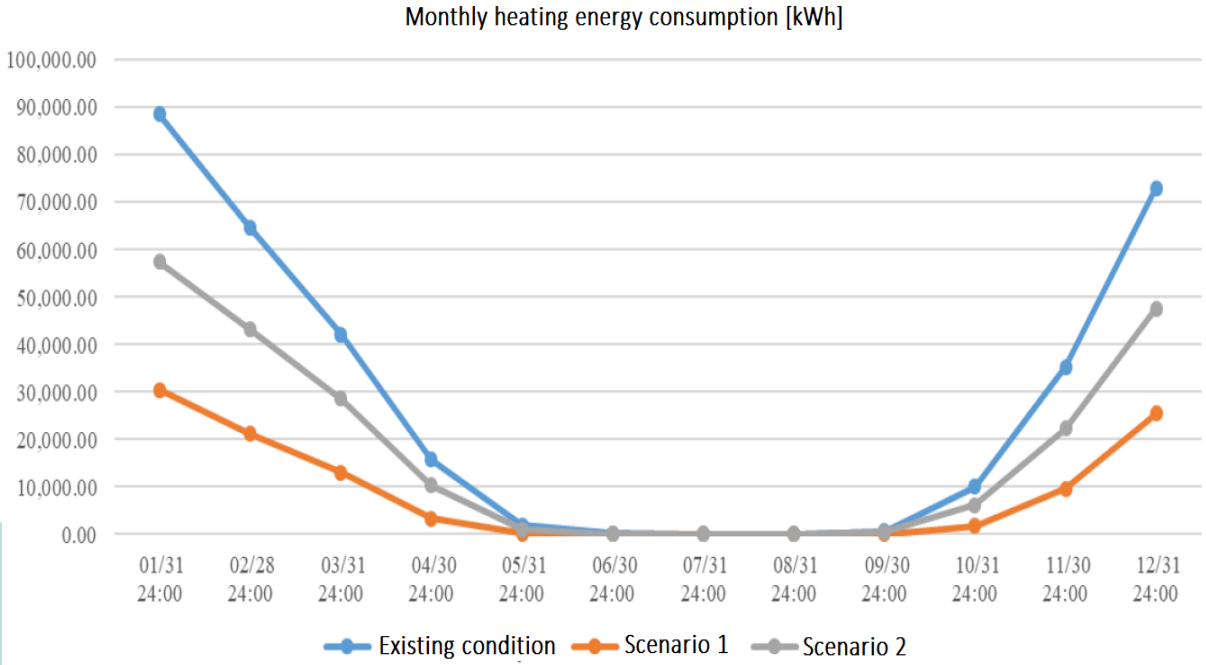


Heating consumption (bills vs. simulation)

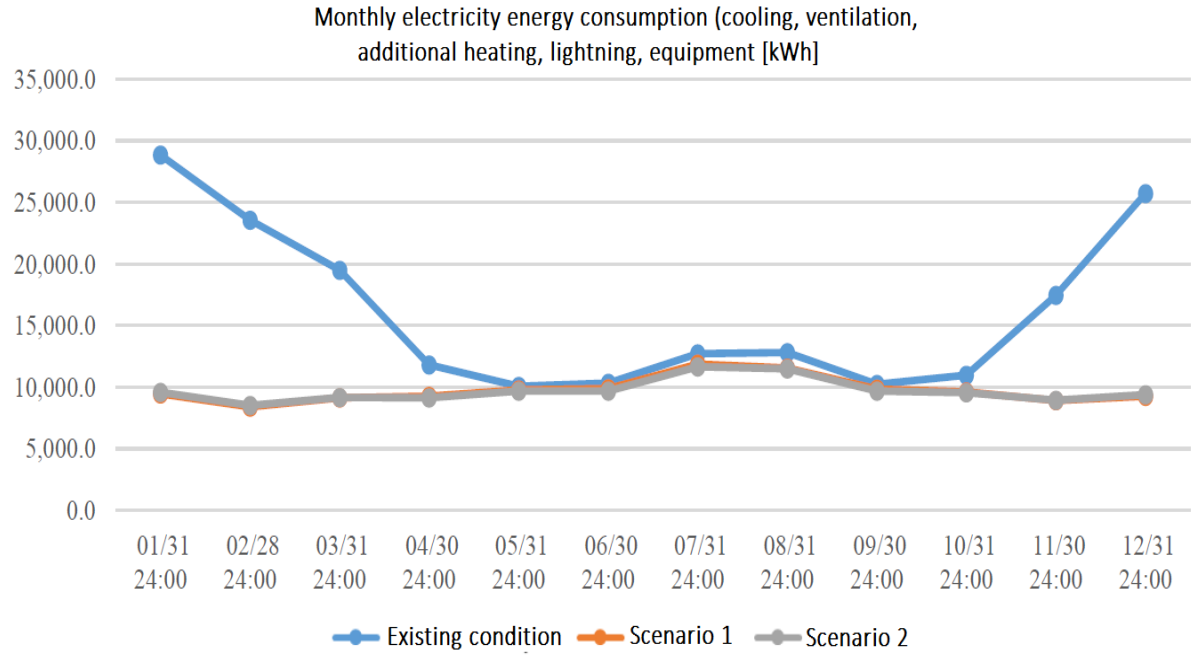
Co-funded by the European Union

5. ENERGY PERFORMANCE SIMULATIONS BEFORE AND AFTER NANOMATERIALS APPLICATION:

5.4. Energy simulation results



Comparisons of monthly **heating energy consumption** between actual scenario and improved scenarios

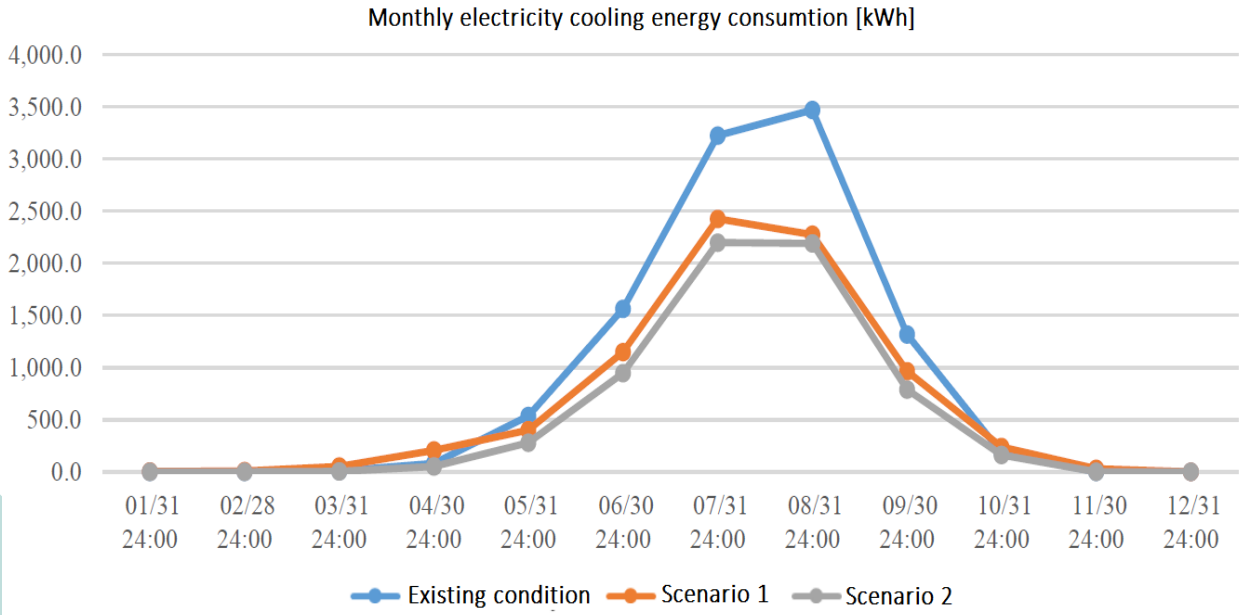


Comparisons of total monthly **electricity energy consumption** between actual scenario and improved scenarios

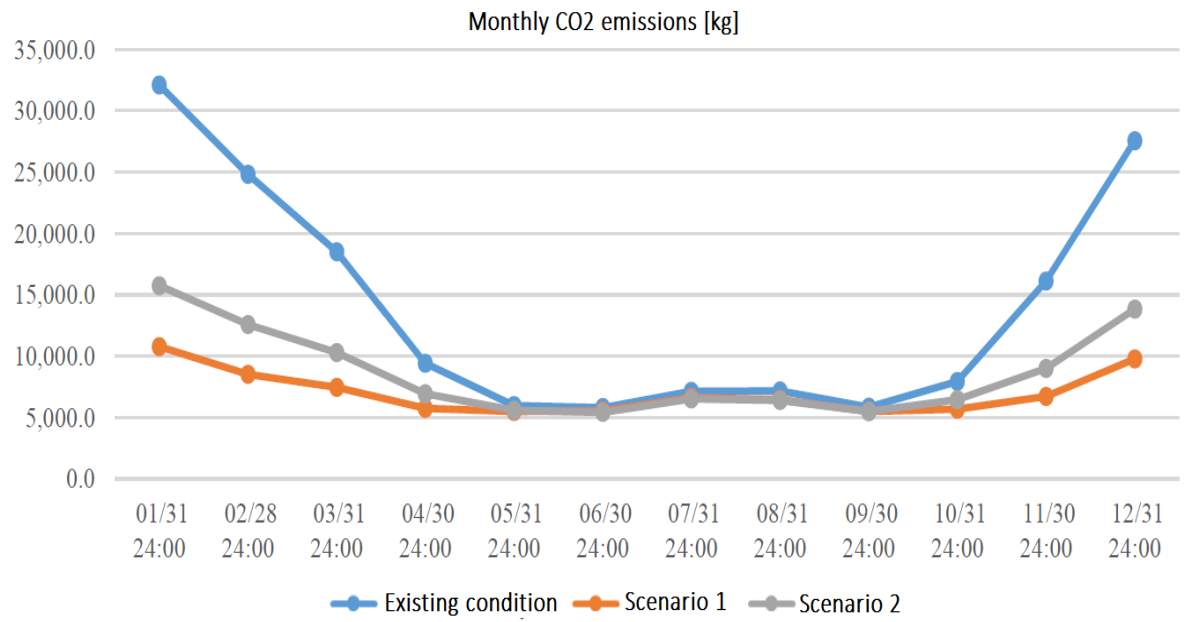
Co-funded by the European Union

5. ENERGY PERFORMANCE SIMULATIONS BEFORE AND AFTER NANOMATERIALS APPLICATION:

5.4. Energy simulation results



Comparisons of monthly **electricity energy consumption for cooling** between actual scenario and improved scenarios



Comparisons of monthly **CO2 emissions** between actual scenario and improved scenarios

Co-funded by the European Union

6. CONCLUSIONS:

The buildings of the post-earthquake period in Skopje represent an important cultural heritage, but are built in lack of insulation materials and consequently, they are large energy consumers responsible for tons of CO2 emissions, don't meet today's criteria for EE and CE practices can hardly be implemented.

The goal was to investigate and suggest methods and measures for proper modernist buildings' renovation, in order to reduce their energy consumption, emissions, financial costs and improve their thermal comfort and lifespan, while keeping their original architectural appearance.

Simulations of the existing condition of the building and the improved renovated scenarios with new façade materials application were made. The results showed that building's energy efficiency is significantly improved in terms of reducing the he9ating energy consumption in both scenarios.

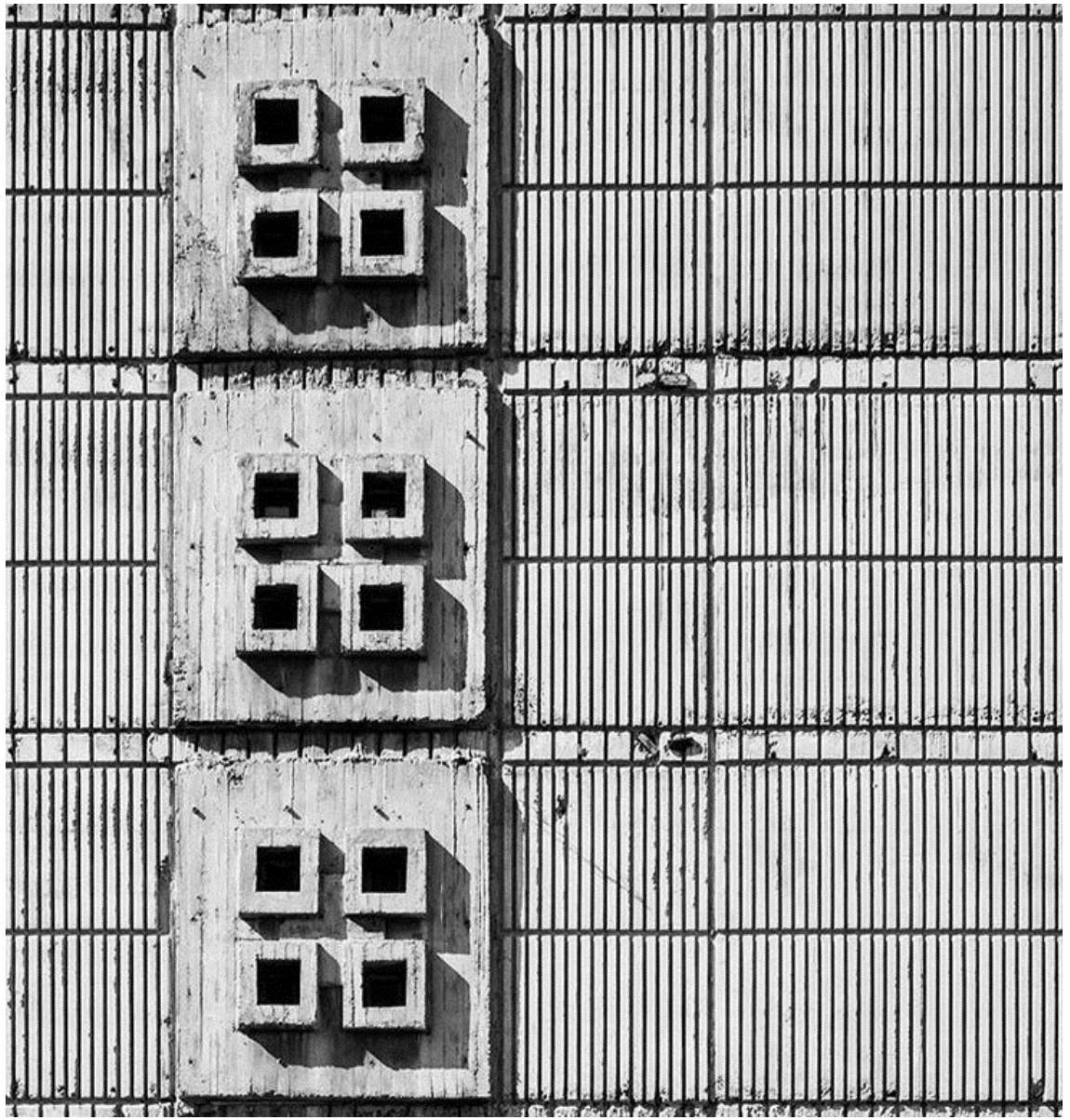
It can be concluded that according to the analyzed indicators, the suggested methodology and materials showed great results in improving both, EE and CE of the modernist buildings heritage.

Comparisons of the main key indicators for energy efficiency improvement for both scenarios with the existing condition

Key indicators	Existing condition	Scenario 1	Scenario 2
Heating energy [kWh]	27 685	8 765.7	18 105
Electricity heating energy [kWh]	6 133.5	2.96	43.9
Electricity cooling energy [kWh]	865.5	646.2	552.6
Total electricity energy [kWh]	16 157	9 736	9 693
CO_2 emissions [kg]	14 022.5	7 017.9	8 683
PM10 particles [kg]	1.3	0.7	0.8

Co-funded by the European Union

Thank you for your attention



dimevska.liljana@arh.ukim.edu.mk

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EACEA. Neither the European Union nor the granting authority can be held responsible for them."