SESSION 7: Healthy Buildings

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Towards Sustainable Healthcare: Zero Energy Building Strategies for Hospitals

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The building sector accounts for about 40% of the total energy consumption and 36% of total CO_2 emissions.

Thus, the sector has a very significant role to perform in implementing the EU Decarbonization objectives by 2050.

Non-residential buildings account on average for 25% energy consumption of the total European building stock, representing a heterogeneous sector compared with the residential.

Large buildings, such as hospitals, consume a lot of energy due to different services.

Hospitals are the most energy-intensive building, as they have several high and continuous loads for electricity, heating, and cooling (including HVAC systems operating under strict comfort conditions, high hot water demand, kitchen facilities, etc).

Identifying the energy behavior of hospitals is a crucial task for determining potential energy savings and developing benchmarks and design guidelines for Nearly Zero Energy Hospitals (ZenH).

The ZenH Balkan Project

This research was conducted as part of the ZenH Project, supported by the INTERREG Balkan-Mediterranean Programme (EU Funds).

The project aimed to facilitate the implementation of the EPBD by defining the characteristics and Standards for Zero Energy Hospitals (ZenH) in the South Balkan region (Greece (coordinator), Albania, Bulgaria, Republic of North Macedonia, Cyprus)

The expected outputs

- Produce benchmarks and design guidelines for ZenH
- Improve the technical capacity of professional groups and government officials towards the ZE buildings notion
- Prepare detailed analysis and test the benchmark models for upgrading 7 hospital buildings into ZEB.

Description of the study

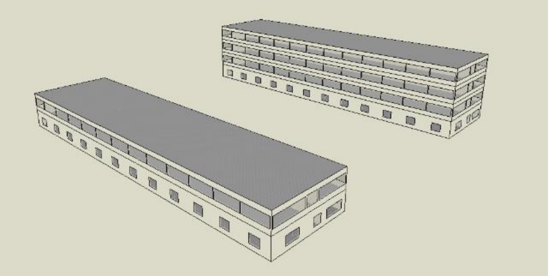
- To study the energy efficiency of hospital buildings and propose models for their transition to Zero Energy Buildings (ZEB), six typologies, based on the building's floor plan, were proposed.
- For each typology, 10 energy upgrade scenarios were investigated.
- Each typology and scenario was investigated for each climatic zone in Greece, using the energy model DesignBuilder for simulations.

Building Typologies

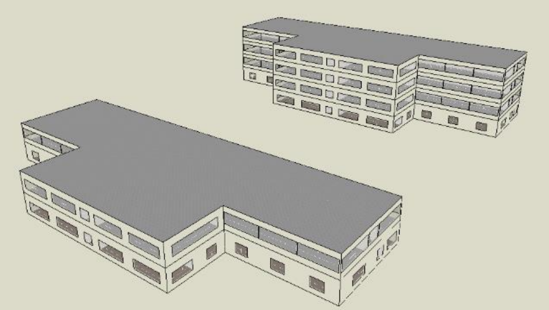
Three building types were investigated (A, B, C), each differentiated by a pair of structural variations and in number of floors, yielding a total of six model typologies. Specifically:

- **Rectangular building, Shape "I.“** The first case (A1) with two floors and an area of 2.000 m^2, while the second case (A2) with four floors and an area of 4.000 m^2.
- **Building shape "T."** The first case (B1) with two floors with an area of 2.600 m^2, and the second case (B2) with four floors with an area of 5.200 m^2. This typology featured an extended section primarily housing administrative offices.
- **Building shape "Γ."** The first case (C1) with two floors with an area of 2.600 m^2, and the second case (C2) with four floors with an area of 5.200 m^2.

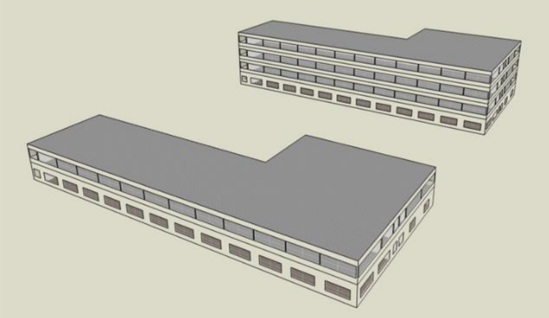
Building Typology A1, A2



Building Typology B1, B2



Building Typology C1, C2

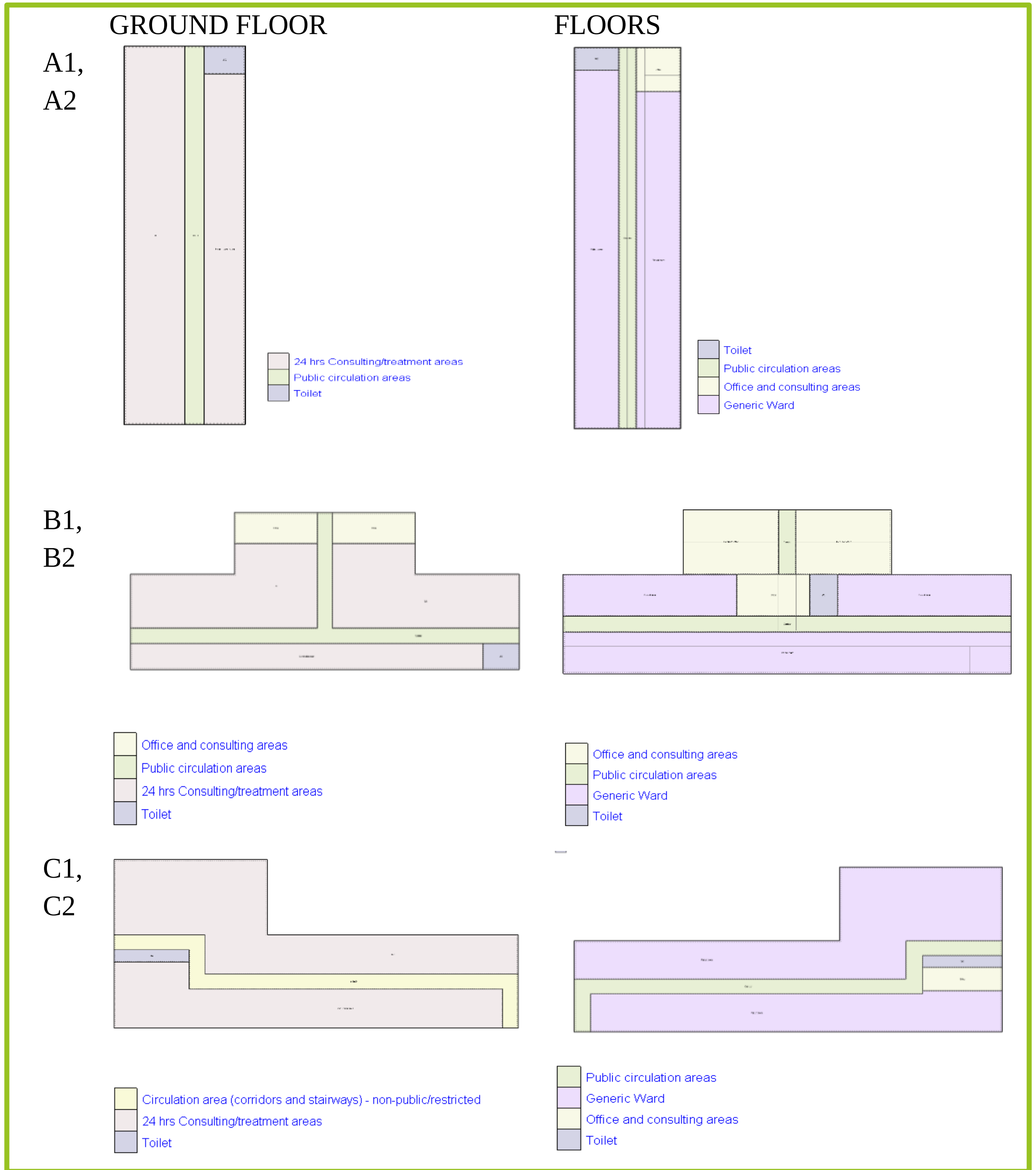


Thermal Zones

The building was divided into "thermal zones," which are spaces with similar use, operating profiles and common electromechanical systems.

The building types were divided into the following thermal zones (TOTEE_20701-1_2017 Chapter 3):

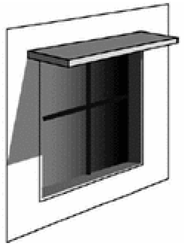
- Patient rooms
- External clinics
- Waiting rooms
- Offices
- Corridors and other common utility areas
- Restrooms



Examined scenarios

Scenario/Description	Details
1. Building constructed before the BTIR (Building Thermal Insulation Regulation) Uninsulated building	
2. Building constructed after the BTIR application Minimum thermal insulation requirements of the building envelope according to the BTIR	
3. Addition of insulation to external walls The objective was to fulfill the maximum allowed thermal transmittance values for individual structural components by climate zone in the case of a comprehensive renovation of the existing building, in accordance with the Building Energy Efficiency Regulation (KENAK)	Climatic Zone: A / B / C / D Maximum permitted thermal transmittance coefficient U [W/(m²·K)]: 0,6 / 0,5 / 0,45 / 0,4 Required insulation thickness (cm): 5 / 6 / 6 / 7
4. Additional insulation to external walls Adding an additional 2 cm of insulation to the external walls beyond that considered in the previous scenario, to assess the advantage of exceeding the insulation standards established by the Building Energy Efficiency Regulation (KENAK)	Climatic Zone: A / B / C / D Insulation thickness (cm): 7 / 8 / 8 / 9
5. Addition of insulation to the roof of the building Adding insulation from extruded polystyrene (XPS) to the roof of the building. The goal was to meet the maximum permitted values of the thermal transmittance coefficient for individual structural components by climate zone in case of a comprehensive renovation of an existing building, according to the Technical Instructions for the Energy Performance of Buildings (TOTEE)	Climatic Zone: A / B / C / D Maximum permitted thermal transmittance coefficient U [W/(m²·K)]: 0,5 / 0,45 / 0,4 / 0,35 Required insulation thickness (cm): 6 / 8 / 8 / 9

Examined scenarios

Scenario/Description	Details				
6. Replacement of building's windows Replacing the windows to meet the maximum permitted values of the thermal transmittance coefficient for windows by climate zone (case of a comprehensive renovation of an existing building, according to KENAK)	Climatic Zone	A	B	C	D
	Maximum permitted thermal transmittance coefficient U [W/(m²·K)]	3,2	3	2,8	2,6
7. Addition of insulation to building's envelope and replacement of windows This scenario represents a combination of scenarios 3, 5, and 6					
8. Addition of insulation to building's envelope, replacement of windows, lighting fixtures replacement, and addition of shading devices to windows Based upon the preceding scenario (7), replacement of existing lighting with LED lighting with a power density of 2.5 W/m² per 100 lux, in accordance with KENAK has been incorporated. Additionally, horizontal shading devices have been integrated into the window frames, with the goal of reducing building's demand for cooling and ensure indoor thermal comfort.					
9. Addition of insulation to building's envelope, replacement of windows, lighting fixtures replacement, replacement of mechanical equipment with more efficient ones In the previous scenario 8, a heating system (boiler) with an efficiency rating of 0.9 and a cooling system (using water as the cooling medium) with an efficiency rating of 2.7 were added, in accordance with KENAK					
10. Coverage of the required electrical energy of scenario 9 with photovoltaic systems For each building typology, the number of photovoltaic panels and the generated electrical energy required were assessed for different scenarios: to meet 20%, 40%, 60%, and 80% of the total electricity demand of each building, as calculated from scenario 9.					

Results

Scenario/Description	Results
1. Building constructed before the BTIR (Building Thermal Insulation Regulation)	Scenario 1 served as the basis for comparison of the results.
2. Building constructed after the BTIR application	Typology A1 shows the greatest savings with a rate of **12%.**
3. Addition of insulation to the external walls	All typologies showed almost the same savings rate of **2-3%.**
4. Additional insulation to the external walls	All typologies showed almost the same savings rate of **2-4%.**
5. Addition of insulation to the roof of the building	Typology C1 shows the greatest savings with a rate of **13%.**
6. Replacement of the building's windows	All typologies showed almost the same savings rate of **3-6%.**
7. Addition of insulation to the building's envelope and replacement of windows	Typology B1 shows the greatest savings with a rate of **20%.**
8. Addition of insulation to the building's envelope, replacement of windows, lighting fixtures replacement, and addition of shading devices to windows	Typology B1 had shown the greatest savings with a rate of **25%.**
9. Addition of insulation to the building's envelope, replacement of windows, lighting fixtures replacement, replacement of mechanical equipment with more efficient ones	Typology B1 presents the greatest overall primary energy savings with a rate of **34%**. The savings on the heating load range from **60%** (Typologies A2, B2) **to 70%** (Typology C1), while in cooling it is **35%** for all building typologies except for B1, where the savings amount to **55%.**

Conclusion/Results

The key outcomes of our study are summarized as follows:

- Implementing energy upgrade measures, such as the enhancement of the building envelope's thermal insulation (including walls, roof, and thermal efficient windows complemented by low-emission coatings), proves to be highly effective.
- The adoption of shading systems and the transition to LED lighting fixtures further contribute to substantial energy savings.
- The replacement of outdated mechanical equipment with modern, energy-efficient alternatives is crucial for reducing energy consumption.
- Across various typologies examined, Typology B1 emerged as the one achieving the highest energy savings rate at 34%.
- The least energy savings were observed in Typologies B2 and C2, with savings rates ranging from 20% to 29%, varying by climate zone. This variance underscores the importance of climate-specific strategies in energy optimization efforts.

Additional proposals

Additional proposals for energy upgrading and implementation of Renewable Energy Systems (RES) for heating and cooling of buildings could be explored.

- Automatic control systems (BEMS),
- Internal shading devices,
- Passive methods such as nighttime ventilation,
- Green roofs

can lead to significant reductions in energy consumption of buildings, as well as RES systems for heating and cooling of buildings, such as solar heating and cooling (solar collectors), geothermal systems, heat pumps.

Furthermore, it would be beneficial for the administration to ensure that **staff have the opportunity to be trained on the new technical data related to energy improvement** of hospital units and the operation of new energy systems, as well as to provide relevant information and advice to visitors.

These findings underscore the feasibility and importance of adopting comprehensive energy upgrading measures to significantly reduce energy consumption in Hospital Buildings.

Our study emphasizes the potential for significant energy savings across different building typologies and climate zones, illustrating a clear pathway towards more sustainable and energy-efficient hospital building operations.

By focusing on thermal insulation, efficient lighting, and the modernization of mechanical systems, and exploitation of RES systems, hospital buildings can achieve or even exceed the targeted savings rates, moving closer to the goal of nearly zero-energy consumption and nearly zero-carbon buildings.

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