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EMEA 2024

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FRIDAY - SATURDAY

NOVEMBER 22-23, 2024

@ 9:00-18:00

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Energy Study and Upgrading of a Secondary Education School Building with the Aim of Creating a Zero Carbon Emissions School Building

Aim of Study

- The study and energy upgrade of a High School in the city of Xanthi to investigate if a school building through appropriate interventions can be transformed into a Zero Carbon Emissions building.
- Investigate the contribution of school buildings to decarbonization of the building stock.

Introduction

- The building sector consumes almost 42% of the total final energy in European Union, representing 35% of energy-related greenhouse emissions (European Environment Agency, 2024).
- The building sector in Greece represents 43% of the total energy consumption (Ministry of Environment & Energy), most of which belongs to the residential sector with a share of 26% in the total energy consumption.
- School buildings in Greece consume approximately 20% more thermal energy than they should. (Droutsa et al. 2021)
- The specific energy consumption of buildings far exceeds the average, often reaching 100-200 kWh/m². This high consumption, especially high for the mild climatic conditions of Greece.

Methodology - Case Study

- Climate data of Xanthi

  - Latitude: 40.98°
  - Longitude: 24.60°

  - C’ Climatic Zone (Heating period: October 15th to April 30th, Cooling period: June 1st to August 31st).
  - Average air temperature for the year 2022: 15.9 ^{o}C.
  - Lowest air temperature : -0.1 ^{o}C and highest temperature: 33.3 ^{o}C.

Methodology - Case Study

- <u>Construction data of the school building</u>

  a) Construction date: 2008

  b) Total area: 2,400 m^2

  c) Conditioned area: 1,839 m^2

  d) Operation: 9 months from 08:15 to 14:15 (Holidays period cover July and August and 15 days during the Christmas and Easter holidays).

  e) Orientation: North-east

  f) Heating System: Oil boiler with an efficiency of 62%. Cooling system not exist.

Structural Elements	U (W/m^2K)
External masonry	0.51
Floor	0.51
Roof	0.46
Wooden roof with tiles	0.40

Table1: Structural Elements

Methodology - Case Study

Examined scenarios

- Scenario 1: Extra insulation, 60mm stonewool on the walls and roof, resulting at a thermal transmittance value of U= 0.26 W/m^2K for the walls and U=0.25 W/m^2K for the roof.
- Scenario 2: Replacement of windows with new ones with low emissivity triple glazing, with air in the gap
- Scenario 3: Replacing existing light bulbs with LED bulbs. Installation of 303 LED lamps of 12W each.
- Scenario 4: Combination of scenarios 1, 2, 3 (Recommended Scenario).
- Scenario 5: Installation of ceiling fans for the cooling period at the existing building. They are only in use in June (in the C' climate zone the cooling period is June to August and the school is closed in July and August).
- Scenario 6: Ceiling fans at the energy upgraded building (Scenario 4).
- Scenario 7: Replacement of the oil boiler with heat pumps for heating and cooling at the energy upgraded building (Scenario 4). (A cooling system is not used in this building)
- Scenario 8: Installation of ceiling fans at the energy upgraded building with heat pumps
- Scenario 9: Installation of PV units, 590 m^2, on the tiled roof with P= 118 kWp (in Scenario 4)

Results

Energy Consumption	Energy Bills	Existing Building	Scenario 1 Envelope Insulation	Scenario 2 Triple Glazing	Scenario 3 LED Lights	Scenario 4 Combination Scenarios 1, 2 & 3
Electricity (kWh)	22,320	21,244	21,241	21,241	18,059	18,053
Heating (kWh)	50,000	48,028	40,750	38,917	47,937	32,238
Primary electricity (kWh/m^2)	35.2	33.5	33.5	33.5	28.5	28.5
Primary heating (kWh/m^2)	29.93	28.7	24.4	23.3	28.7	19.3
Total Primary Energy (kWh/m^2)	65.13	62.2	57.9	56.8	57.2	47.8
Total Primary Energy (kWh)	119,769	114,399	109,418	104,377	105,094	87,808

Table 2: Energy simulation results and scenario comparison

Results

Scenario No	Cooling Load (kWh)	Heating Load (kWh)	Heating consumption (kWh)	Cooling consumption (kWh)
Existing building	3,760	7,801	12,189	836
5: Fans installation	2,691	7,801	12,189	598
Energy upgraded building	2,461	3,703	5,784	547
6: Fans installation	1,661	3,703	5,784	369
7: Heat pumps	2,389	3,727	745	498
8: Heat pumps+ fans	1,684	3,727	745	351

Table 3: Cooling - heating load and energy consumption without and with ceiling fans

Results

CO_2	Existing building	Scenario 1 Envelope insulation	Scenario 2 Windows change	Scenario 3 LED bulbs	Scenario 4	Scenario 9 PVs
(tn/year)	46,77	44,66	44,12	41,86	37,26	8,50
% reduction		-4,50%	-5,67%	-10,50%	-20,33%	-81,83%

Table 3: Reduction of CO_2 emissions

Results

Scenario No	Cost of Intervention	Financial Benefit/year	Payback Time (years)
1: Envelope insulation	20,235 €	870 €	23.3
2: Windows change	56,100 €	1,091 €	51.4
3: LED lamps	2,273 €	898 €	2.5
4: Combination Scenario (1, 2 & 3)	76,637 €	2,545 €	30.1
5: Ceiling fans installation (before energy upgrades)	5,530 €	48.7 €	113.5
6: Ceiling fans installation (after energy upgrades)	5,530 €	36.4 €	151.9
Scenario 9: PV installation with combined scenario 4	216,637 €	7,083 €	30.4

Table 4: Financial Data of Scenarios

Conclusions - Discussion

- Necessity to accelerate energy upgrades in school buildings and re-approach the design of new schools according to modern data.
- A necessary condition for reducing the consumption of primary energy in electricity is the use of Renewable Energy Sources. Succeeding in this way and the reduction in Carbon Dioxide emissions, achieving our goal of a school building with zero Carbon emissions.
- Use of simple applications (ceiling fans) significantly reduce (32%) the cooling load of the building.
- It is considered important to educate the school staff and students on the correct use of energy and ways to save it.
- The study also showed that the energy upgrading processes in a school building are hindered by bureaucratic procedures.

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THANK YOU!

Q & A

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