Transformation of the listed building hosting the ”Constantin Xenakis” Museum into a nearly zero energy building

Argiro DIMOUDI, Assoc. Professor,
Vavalos P. , Stathis V., Theofylaktos K.
Democritus University of Thrace, Xanthi, Greece

1st Publicity Event
Serres, 01.06.2018

INVESTORS IN CULTURE for fighting crisis

The Project is co-funded by the European Regional Development Fund and by national funds of the countries participating in the Interreg V-A “Greece-Bulgaria 2014-2020” Cooperation Programme.

MUSEUMS represent the culture, tradition, customs and customs of man and that is why they are a very important subject of study. The museums are buildings that are visited by millions of visitors everywhere in the world and are also converted into landmarks and symbols of the region (Tombazis A., 2004).

The great recognition they enjoy from the public has made them an integral part of the **economy** of the particular place, as tourism is growing and booming. Their expressive and **educational character** attracts thousands of tourists who also help the region's well-being (Papadopoulos A., Avgelis A., Santamouris M., 2003).

Acropolis Museum

These buildings host objects of great cultural value from different cultures and therefore have the **essential role of educating and educating the people of society** (G.Ehin, 1998). They are **a way of communication**, and they are aimed at spreading culture.

The complex and multifaceted operation of these buildings results in the consumption **of large amounts of energy**. Instead, materials and electromechanical equipment are required to ensure the necessary conditions for both people and works of art (Farreny R. et al, 2012)

Delphi Museum

The category of museum buildings, as opposed to the other categories, presents many difficulties in the study and **implementation of energy saving methods**.

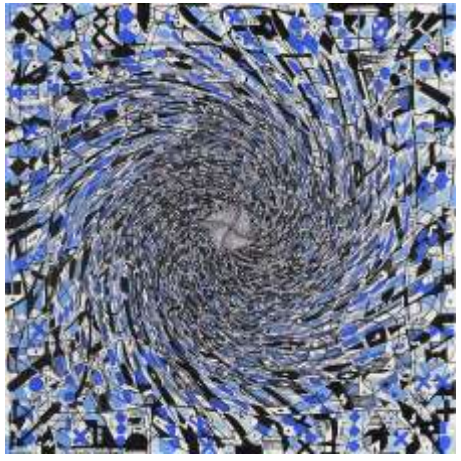
Inside a museum there are many spaces with different uses such as offices, warehouses and exhibition spaces, each of which requires precise and detailed design (C.V. Horie, 2005, S. Keene, 2002).

The museum, in addition to the employees working there, receives many visitors daily, for which it is essential that the appropriate **thermal conditions are in place**.

However, the design of a building to provide such conditions is not easy, as it is necessary to take into account the appropriate conditions that must prevail in the exhibition area in order not to suffer deterioration and alteration of the works of art (G. Thomson, 2003).

CONSTANTIN XENAKIS ART MUSEUM

An Art Museum dedicated to the internationally known Greek artist **Constantin Xenakis** will be created in Greece with permanent exhibition of pieces of his art.



Location

The museum will be located in an existing building of the former camp "Papalouka" in Serres, a city in Northern Greece,
where the whole area according to the General Urban Plan is intended for cultural and recreational activities.

Aim of the energy upgrade of the building

The proposed interventions aim to energy upgrading of the building to achieve the goal of the **"Nearly Zero Energy Building (NZEB)"** (primary energy consumption <60 kWh / m^2 as defined by CRES*).

The interventions concern:

- Energy savings - Energy consumption reduction
- Interventions in the building shell
  - Thermal insulation
  - Low thermal characteristics windows
- Implementation of RES - for achieving the NZEB objective
- Interventions in electromechanical equipment

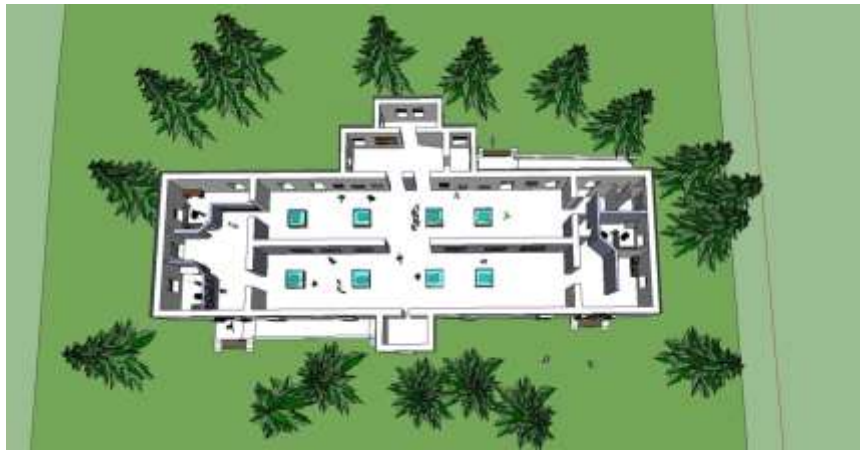
* Centre for Renewable Energy Sources (CRES)

Building Description

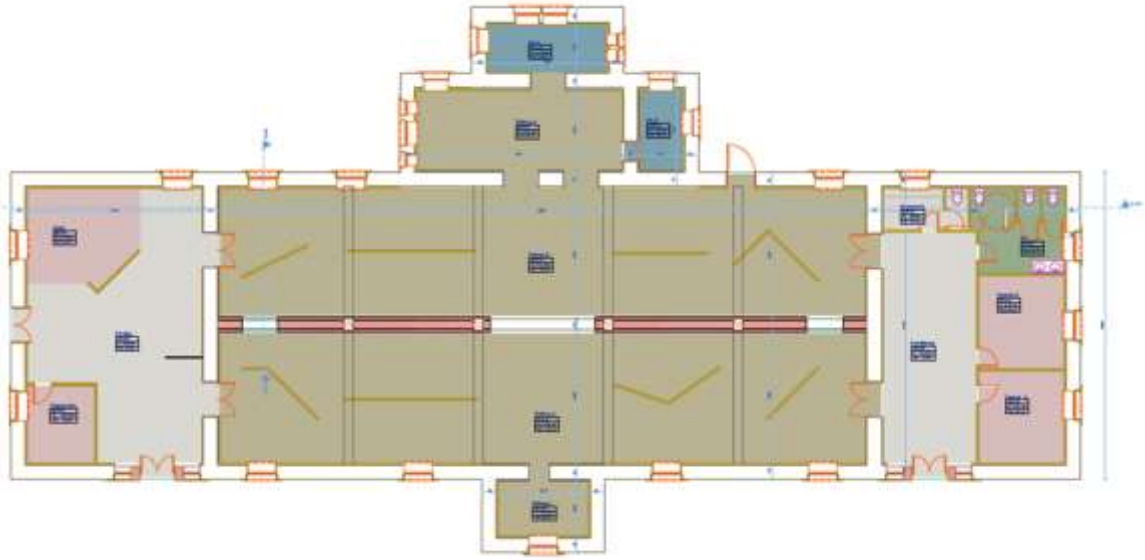
It is a **listed building**, built during the Ottoman period and is of eclectic architecture.

It is an elongated, one-storey building with the longitudinal side on the N – S axis

- Total area: 652 m^2.
- Height: about 5.00 m (internal height 4.70 m)



Panoramic view of the interior



N & W Facade

W Façade

Building Envelope Characteristics

The envelope of the building is:

- Not insulated ,
- Masonry wall, total thickness 60 cm,
- Flat roof made of composite slabs with concrete and iron reinforcements
- Ground floor on soil with concrete slab.
- All walls are coated with plaster internally and externally
- There are decorative elements around the openings and at the corners of the walls.
- Wooden framed openings (doors and windows), with single glazing and upholstered skylight.
- External wooden shutters in windows.

Building's Energy Features

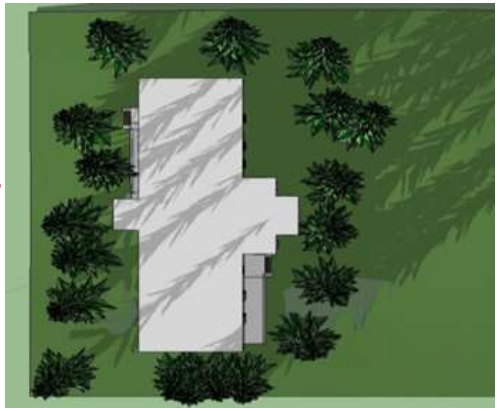
Shading

- Building's shading is mainly obtained by natural obstacles, since on its eastern side there is a building of the same height as the building under study, and around its sides there are planted trees with a height bigger than the building.

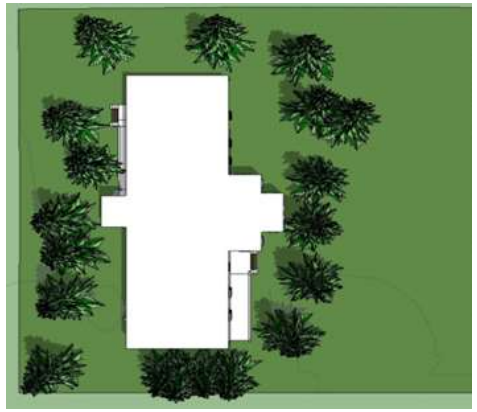
- It also has external shades (wooden shutters).

Natural shading

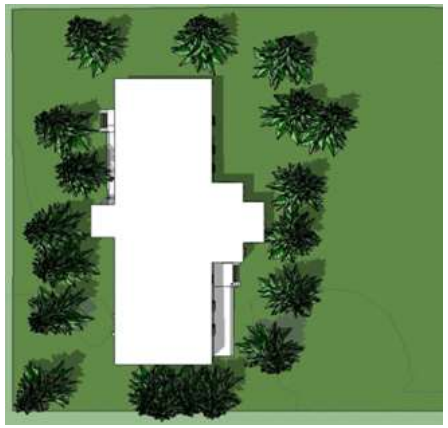
Summer 1/6



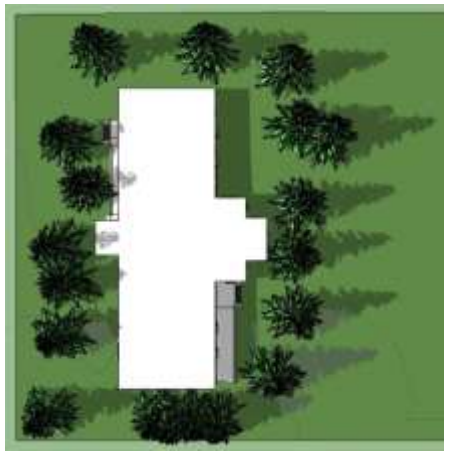
09:00



11:00

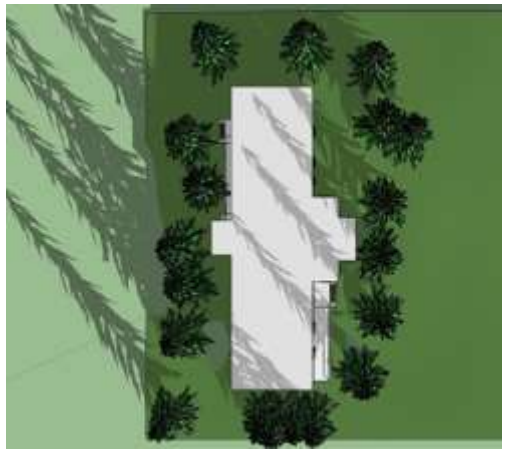


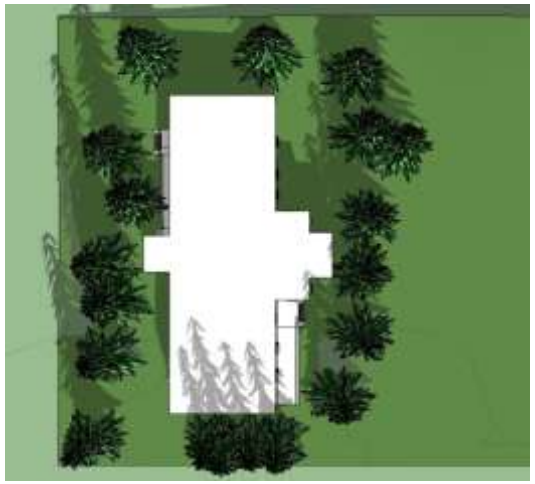
13:00

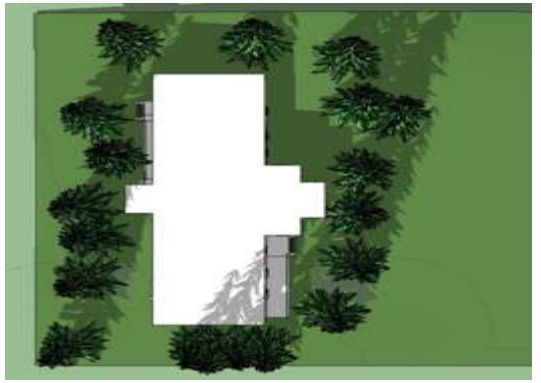


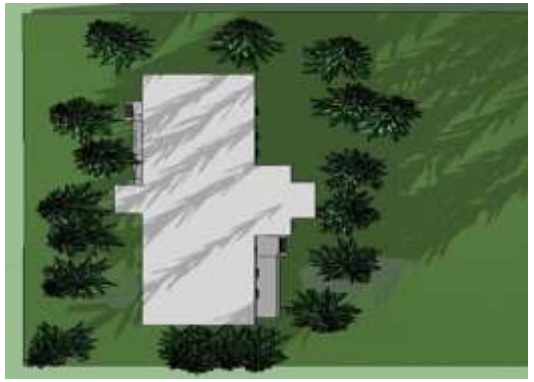
15:00

Winter 1/12









Existing condition

The energy consumption of the building before interventions (assuming a heat pump with thermal and cooling coefficient of efficiency COP = 3,5 and EER = 3,0 respectively) is :

Maximum thermal power (kW)	Maximum cooling power(kW)	Energy consumption (kWh)	Energy needs (kWh)
80,8	64,6	40.233	124.642

The specific energy consumption (EC) and primary energy consumption (PEC) of the building (in kWh/m^2) before interventions are:

EC = 61,71 kWh/m^2 and

PEC = 178,04 kWh/m^2

Proposed Energy Efficiency Interventions

The overriding **priority** is to **reduce energy losses**. Suggested measures :

- **Thermal insulation** of building envelope
  - Walls: 8 cm thick rockwool, positioned on the inner side
  - Roof: thermal insulation and waterproofing with 10 cm thick extruded polystyrene insulation on the external roof side
  - Floor: Extruded polystyrene, 5 cm thick.

- Replacement of **windows** with new ones with low thermal characteristics (double glazing, with one low-e glass sheet and inert gas in the gap).
  - The windows will be opened, with a reclining skylight.
  - The new frames will be wooden and will faithfully follow the design of the existing frames (horizontal and vertical beams)

Energy consumption - Interventions in the envelope

The energy consumption of the building after thermal insulation (assuming a heat pump with thermal and cooling coefficient of efficiency COP = 3,5 and EER = 3,0 respectively, the same as the non-insulated building)

Maximum thermal power (kW)	Maximum cooling power(kW)	Energy consumption (kWh)	Energy needs (kWh)
49,1	53,1	12.961	39.609

The specific energy consumption (EC) and primary energy consumption (PEC) of the building (in kWh/m^2) after the interventions in the building envelope (thermal insulation, windows) are:

EC = 19,88 kWh/m^2 and
PEC = 57,65 kWh/m^2

The primary energy consumption of the building, taking into account the overall lighting load (7.8 kWh / m^2), remains above 60 kWh / m^2.

Proposed Interventions – RES use

Proposed interventions:

- Installation of a closed, horizontal layout, geothermal heating and cooling system with fan coil units in the office zone and vendor zone and Central Air Conditioning Unit (CCS) in the exhibition area.

- The proposed geothermal heat pump (GHG) has:
  - thermal capacity 58,22 kW with a power factor of 3.8 and a total consumption of 15.9 kW
  - cooling capacity of 52.6 kW with a power factor of 3.8 and a total consumption of 11.55 kW.

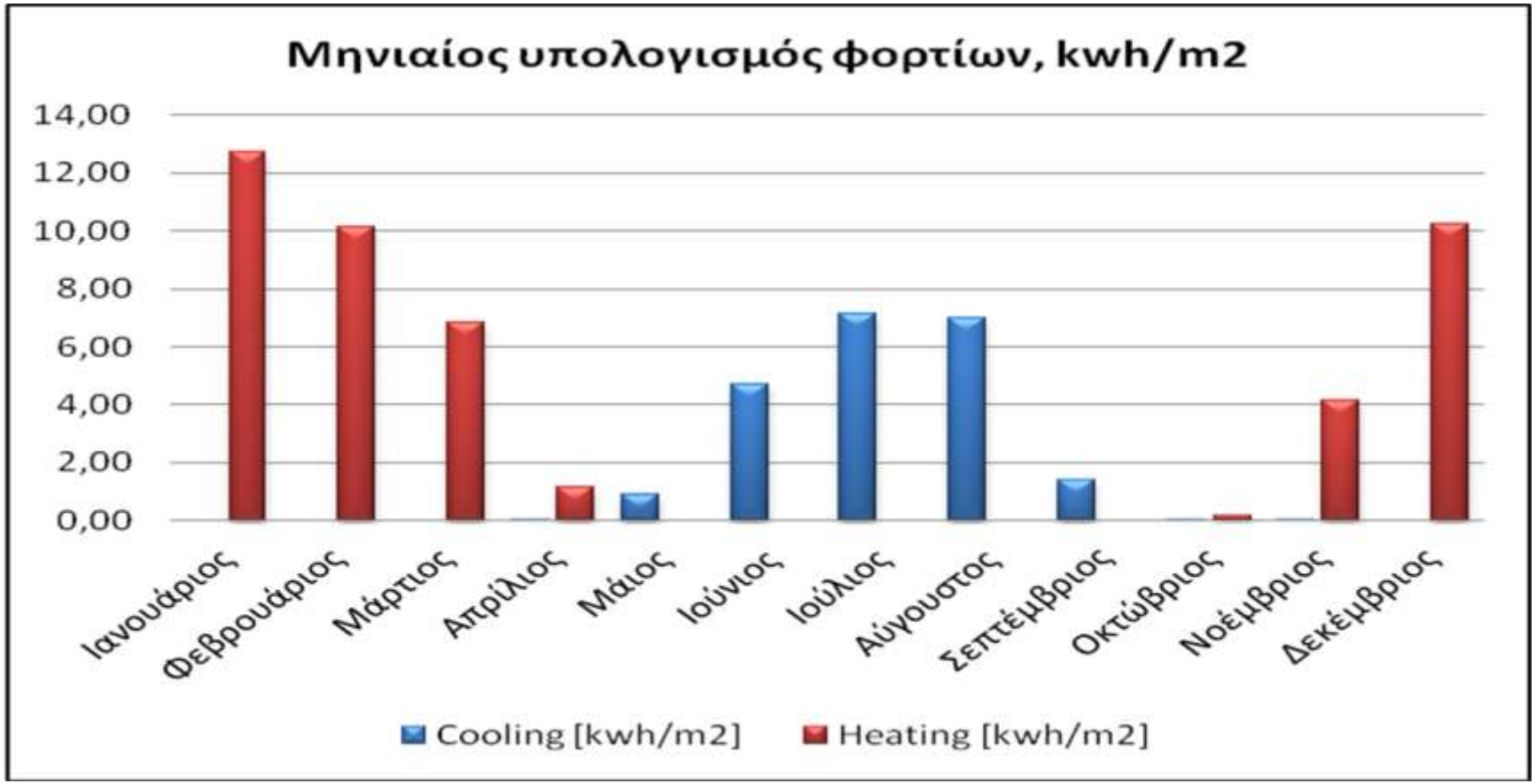
Energy Consumption – Geothermal Energy

Maximum thermal power (kW)	Maximum cooling power (kW)	Energy consumption (kWh)	Energy load (kWh)
49,1	53,1	10.235	39.609

The specific energy consumption (EC) and primary energy consumption (PEC) of the building (in kWh/m2) after the integration of the geothermal heat pump is:

EC = 15,70 kWh / m²
PEC = 45,52 kWh / m²

Taking into account the consumption of general lighting in public areas (7.8 kWh / m2), **the primary energy consumption is 53.33 kWh / m².**



Monthly energy loads after building's energy upgrade

Conclusions

- The total energy savings achieved in the heating and cooling load as a whole due to energy upgrade of the building envelope are 68,22%, which corresponds to savings of 69,29% for heating and 66,63% for cooling.

- The total reduction is estimated at 130,42 kWh / m^2, which corresponds to 79,32 kWh / m^2 in thermal loads and 51,10 kWh / m^2 to cooling loads.

- With regard to energy consumption, energy savings are 74,94%.

- Energy efficiency measures and RES systems applied in the building can transform it into a **NEARLY ZERO ENERGY BUILDING**.

Thank you for your attention!

www.culturaldipole.eu
www.facebook.com/culturaldipole
interreg@culturaldipole.eu.

The project is co-funded by the European Regional Development Fund and by national funds of the countries participating in the Interreg V-A "Greece- Bulgaria 2014-2020" Cooperation Programme.