Capstone Design Project: A Methodology Approach Towards Sustainable Energy Retrofit Solutions in Cyprus

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Research Framework

In the framework of the Interdepartmental Postgraduate Programme «**Energy Technologies and Sustainable Design**» (IPP-ETSD), hosted by the University of Cyprus, the Capstone Design Project (POL 604) aims at applying a holistic design approach to building energy retrofit. Multidisciplinary teams consisting of architects, mechanical, electrical and civil engineers, are merged in order to propose sustainable energy retrofit interventions in an existing public building used for educational and office purposes located in Nicosia. The building is an example of a typical construction from the late 1970s.



Methodology approach

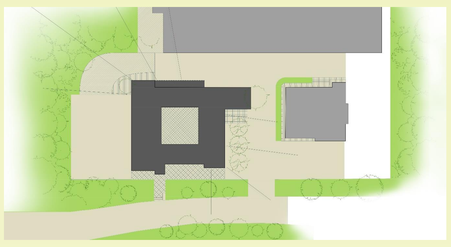
Building analysis

The first stage of the methodology consists of a thorough analysis of a series of **climatic**, **architectural, construction and functional attributes** of the building;

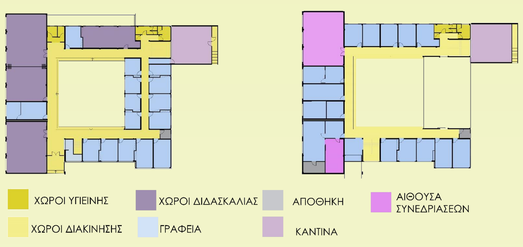
- Architectural layout,
- operation scheme,
- building materials,
- surrounding environment,
- HVAC systems,
- insolation and local wind conditions.

Preliminary in situ audits, climate data analysis, and end user interviews are used in order to estimate the existing functional and comfort requirements.

Topographic plan



Ground Floor plan

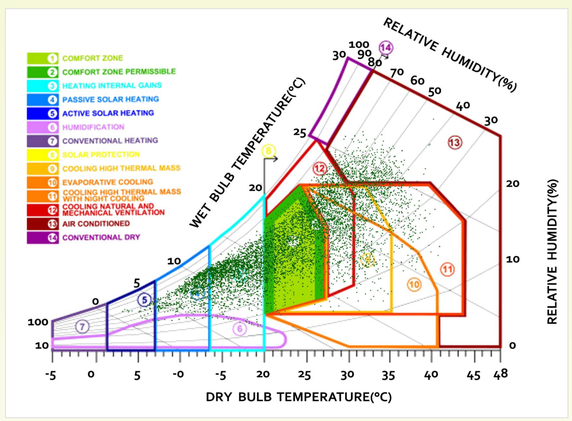


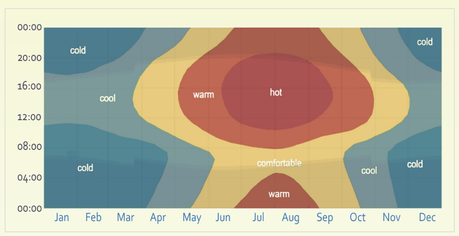
First Floor plan

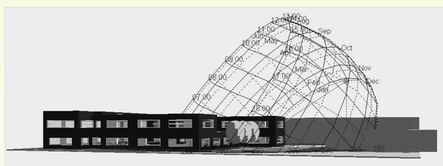
Climate analysis

Cyprus has a rather warm and temperate climate with hot summers and moderate winters. A main climatic characteristic is the large temperature fluctuation between day and night. The prevailing winds are southwest and east during the winter, and west and north during the summer. In the winter, during night-time throughout the year, relative humidity varies between 65% and 95%. During noon in the summer period, relative humidity falls to 30%.

- **During winter period, thermal insulation** and **internal gains** can contribute to the achievement of thermal comfort during daytime. During the coldest months, i.e. December and January, **active solar gains** are also required.
- **During the summer period,** the appropriate design strategies are **shading**, **day and night ventilation** and evaporative cooling. The strategy of **thermal mass** is also considered beneficial, provided that this is combined with shading strategies and night ventilation.



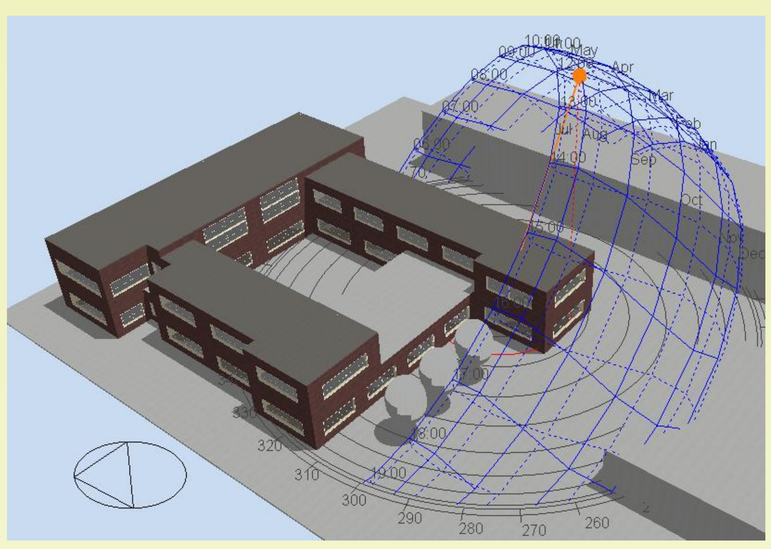


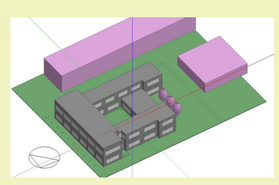
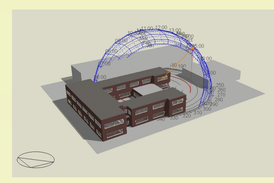
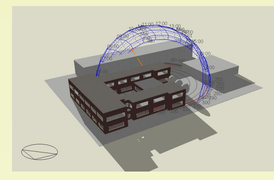


Modelling & Simulation

The following methodological stage, concerns the **modelling** and **dynamic simulation** of the building, using the EnergyPlus software. The simulation provides detailed calculation of the heating and cooling consumption in hourly base time-steps.

In this way, a comparative analysis of various **parametric design solutions** and intervention scenarios is enabled.



Energy retrofit interventions

Energy retrofit proposals focus on passive and active means. Interventions on the building envelope aim at reducing heating and cooling needs, increasing thermal comfort conditions and improving building's aesthetic.

Interventions on the **building envelope**:

- Insulation of building's façades and roof
- High efficient external openings (glasses and frames)
- Dynamic and/or static shading
- Smart-responsive façades
- Green roof & façades

Interventions on **electromechanical equipment** increase the energy performance of the building by reducing the primary energy consumption and the associated greenhouse gas emissions.

- High efficiency air-or ground-source heat pump system
- Installation of an integrated PV system containing elements on roof/facades/sunshades
- LED lighting technology
- Decentralized ventilation and heat recovery system