EULiST Blended Intensive Program

"Monitoring clean energy in the EULiST campuses"
Online and Onsite in Athens, NTUA

Koronaki Irene (NTUA)
Professor

20.06.2023

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

I. The Importance of Campus Sustainability :

Sustainability in higher education is important

- promotes environmental responsibility,
- contributes to climate change mitigation,
- provides educational opportunities,
- generates cost savings,
- engages the campus community, and
- enhances the institution's reputation.

Create a more sustainable and resilient future

Transform our campus into a model of environmental responsibility

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Example of a Sustainable Building with Silver LEED Certification

ASHRAE 2021
INTERNATIONAL DESIGN COMPETITION
INTEGRATED SUSTAINABLE BUILDING DESIGN CATEGORY
SECOND PRIZE FOR NTUA

INTEGRATED SUSTAINABLE BUILDING DESIGN

CAMPUS BUILDING
IN BRITISH COLUMBIA CANADA
University of Northern British Columbia, Prince George

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency:

Energy-efficient practices in NTUA Zografou Campus

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

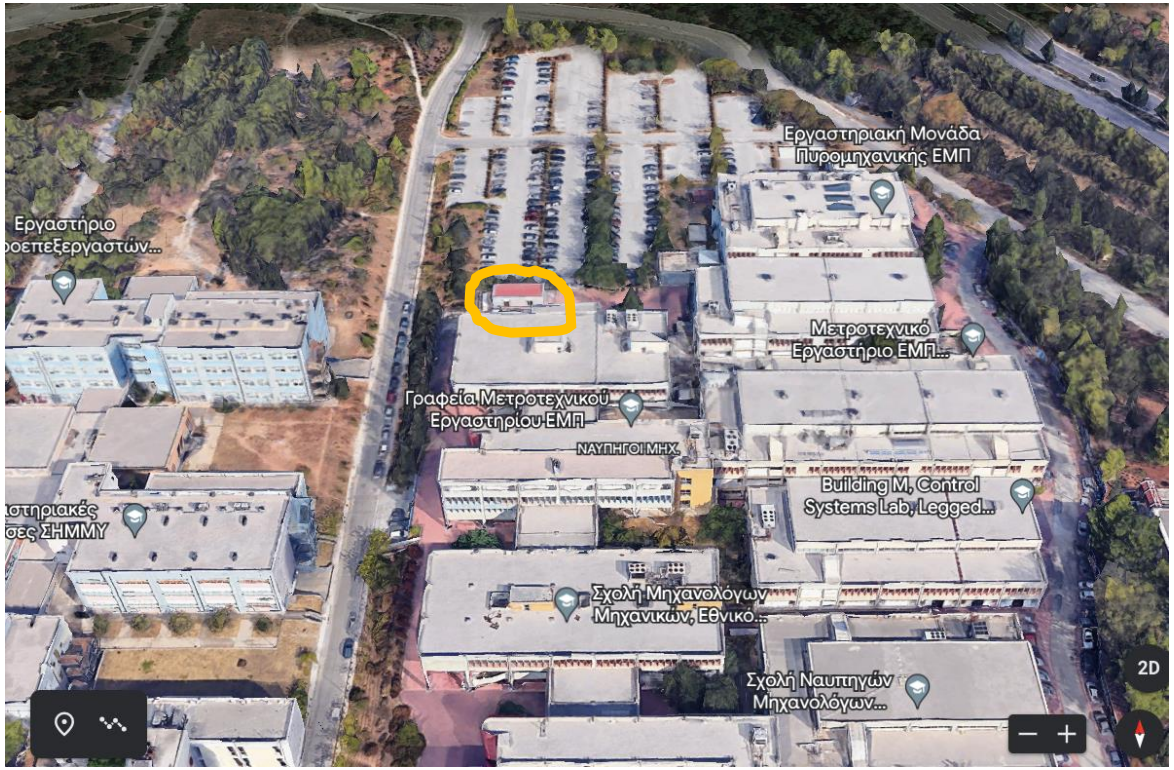
II. Energy Efficiency:

NTUA Premises

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

NTUA Premises



ZEB LIVING LAB

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

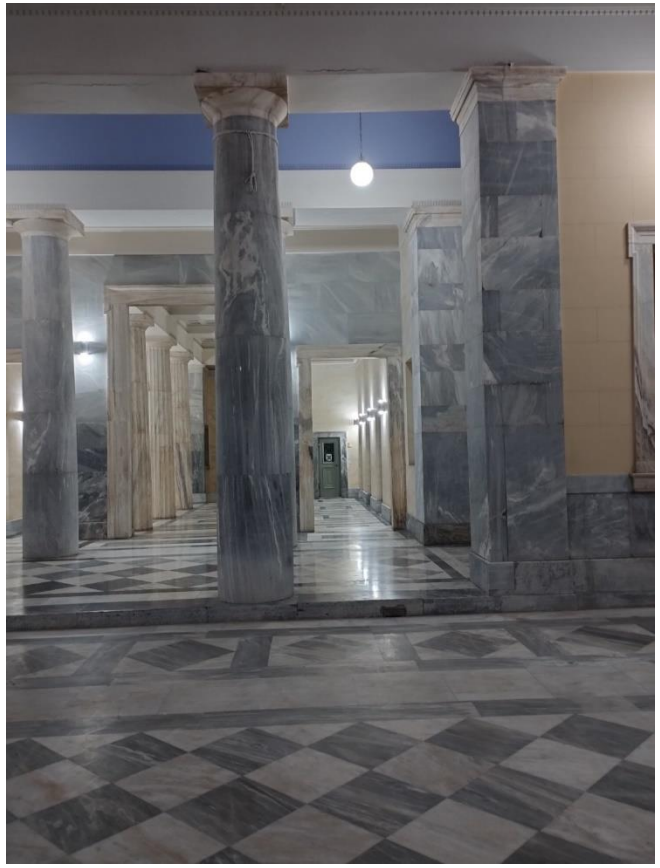
II. Energy Efficiency: Energy-efficient practices in NTUA Zografou Campus

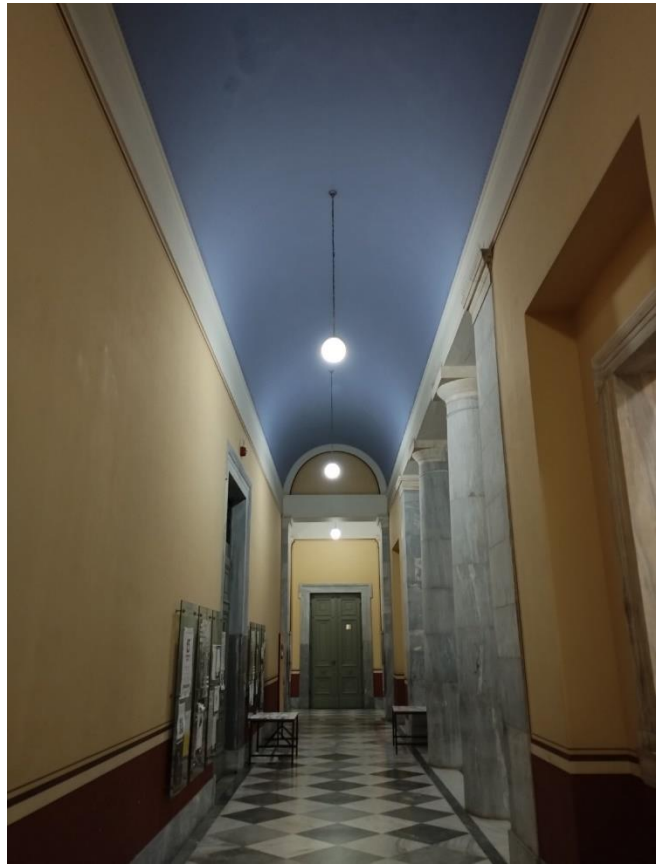
Lighting the facades of the historical complex

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

Restoration of lighting in the atrium of the Averof Building





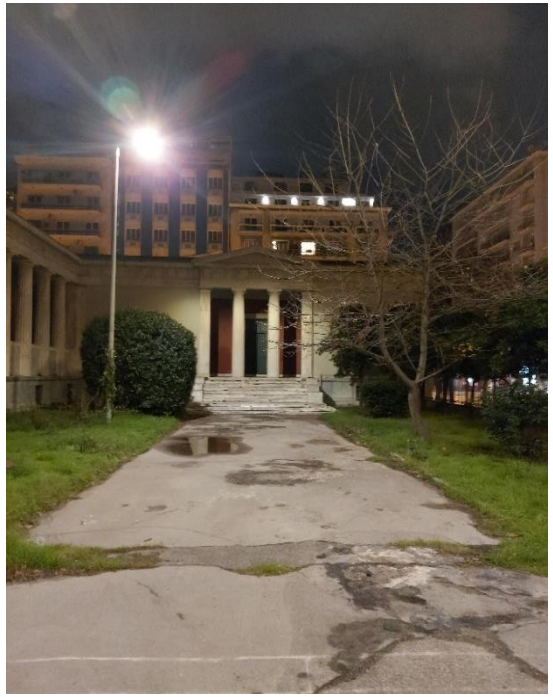

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

Restoration of the Electrical System in the Bouboulina Building after a long-term breakdown & installation of LED lighting

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

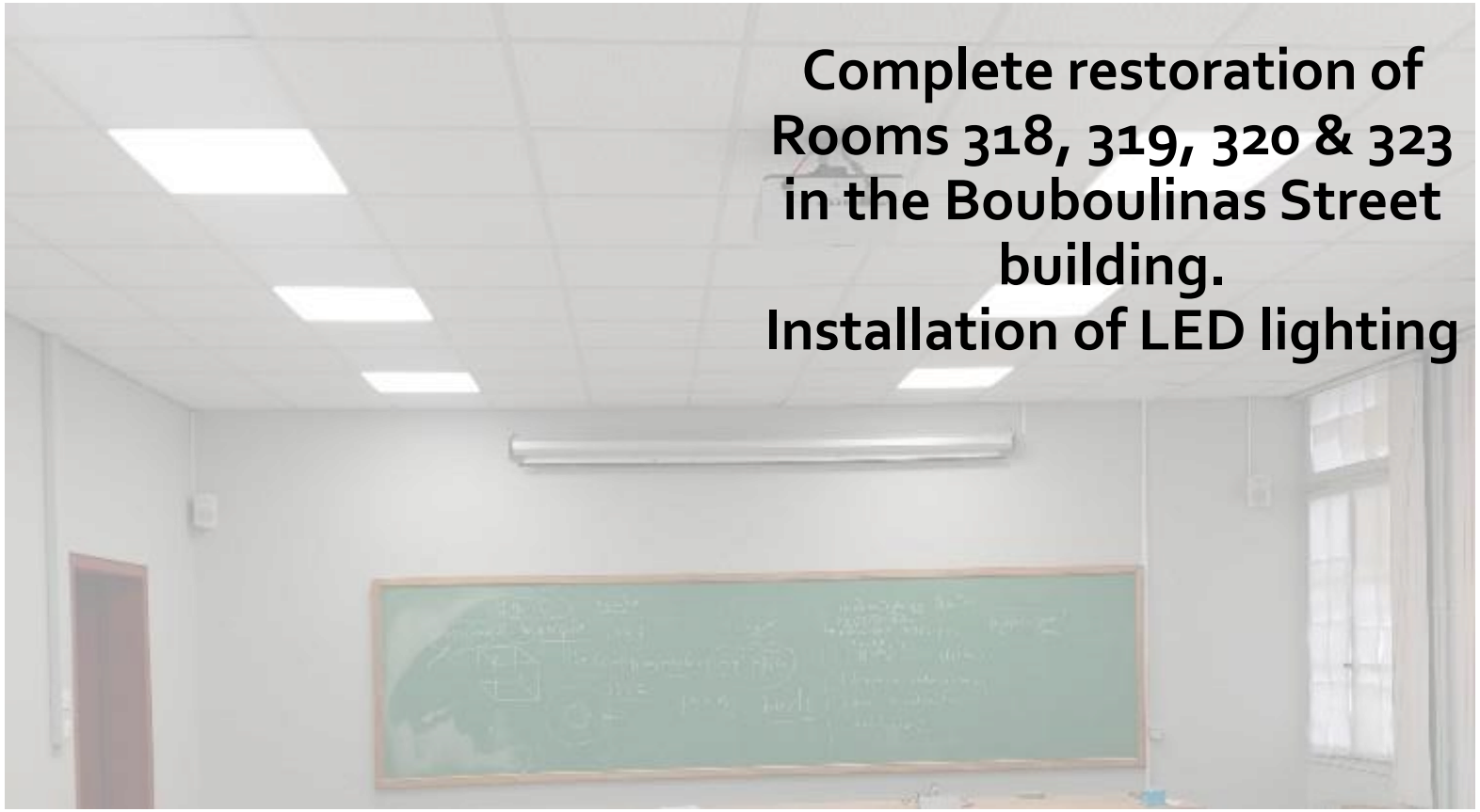
Building a Sustainable Campus: A Pathway to a Greener Future:



Restoration of general lighting of the historical complex of Patision Street with LED lighting fixtures

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:



Complete restoration of Rooms 318, 319, 320 & 323 in the Bouboulinas Street building.
Installation of LED lighting

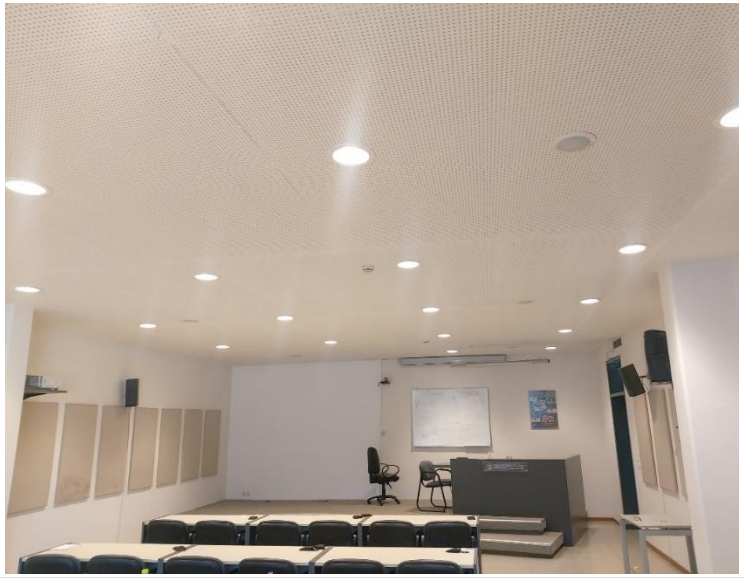
Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

Restoration of the Central Library's electrical system and installation of LED lighting fixtures

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:



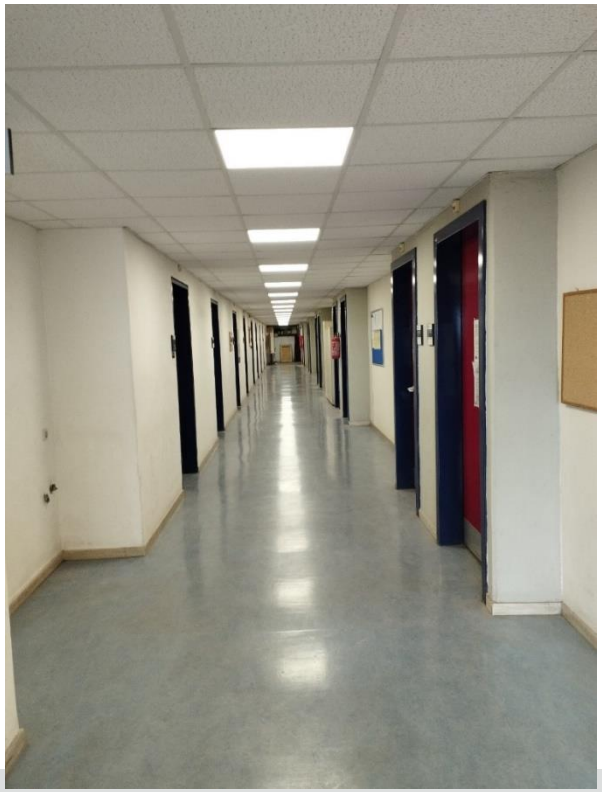
Rehabilitation – Modernization of Multimedia Rooms in the Central Library

- Maintenance - restoration of premises
- Installation of LED lights
- Equipment replacement/upgrade

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

Installation of 1,166 LED lights in the complex of buildings of SME & SNME



- Installed power 38.33kW<120.27kW of existing
- Energy savings 68.1%
- Increased lighting efficiency, low glare and ideal visual comfort

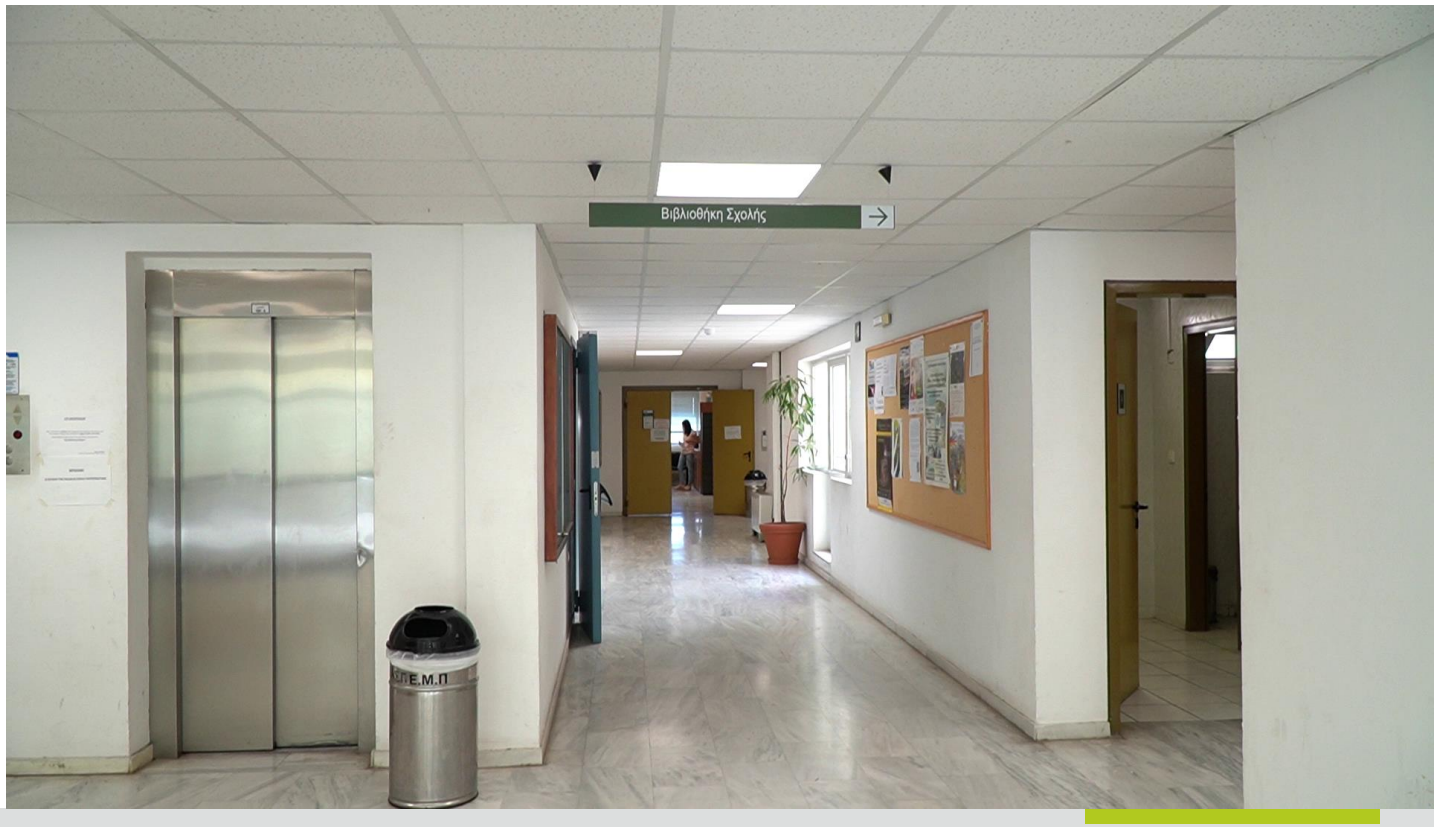
Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

Replacement of all lighting systems with LED

Administration Building - NTUA

BUILDING OF RURAL SURVEYING AND GEOINFORMATICS-ENGINEERING



Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency:

Utilizing renewable energy sources

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: PVs

There are **already implemented** a 20kW photovoltaic system at the south side and on the roof of the Central Library,

a **50kW photovoltaic system** at the south side of the School of Chemical Engineering,

a **10kW photovoltaic system** at the parking of the School of Electrical and Computer Engineering,

a **15kW photovoltaic system** on the roof of the School of Mining and Metallurgical Engineering (under installation) and a 2kW photovoltaic system on the roof of the Central Administration.

A **Geothermal Energy system** is also installed near the School of Mining and Metallurgical engineering.

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: PVs

Electrolyzer for upgrading the PVs in the School of Chemical Engineering through the production of hydrogen

Building a Sustainable Campus: A Pathway to a Greener Future:

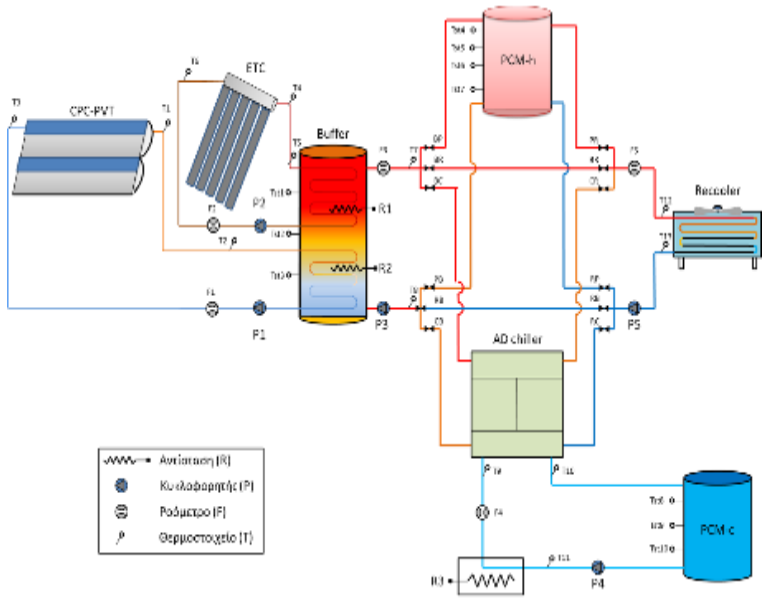
II. Energy Efficiency: Geothermal Energy System

A **Geothermal Energy system** is also installed near the School of Mining and Metallurgical engineering.

Hybrid geothermal system connected to HVAC equipment at NTUA building

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Solar Cooling applications in Mechanical Engineering School



Tube Solar Collector

PVT collector

Rated power 10 kW

Thermal efficiency COP=0.5

Adsorbent Zeolith

Hot water inlet temperature from PVT 55oC

Hot water inlet temperature from vacuum collectors 95oC

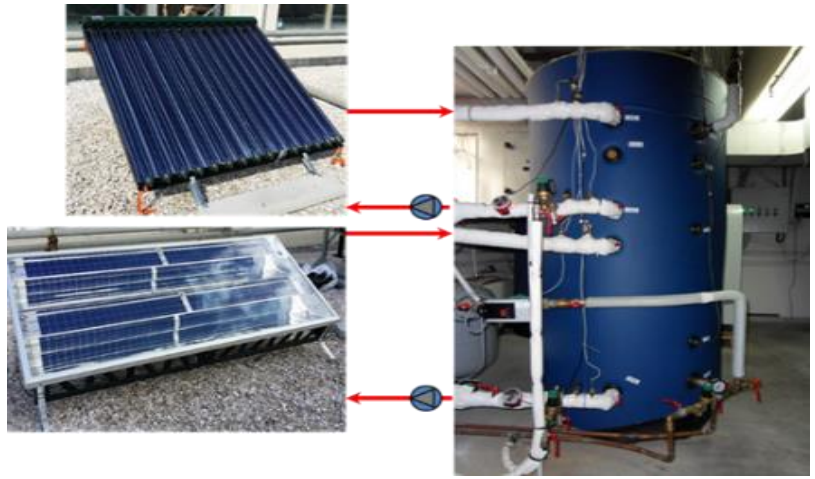
Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Solar Cooling applications in Mechanical Engineering School

- *Production of thermal energy from vacuum solar collectors and hybrid thermophotovoltaic collectors.*

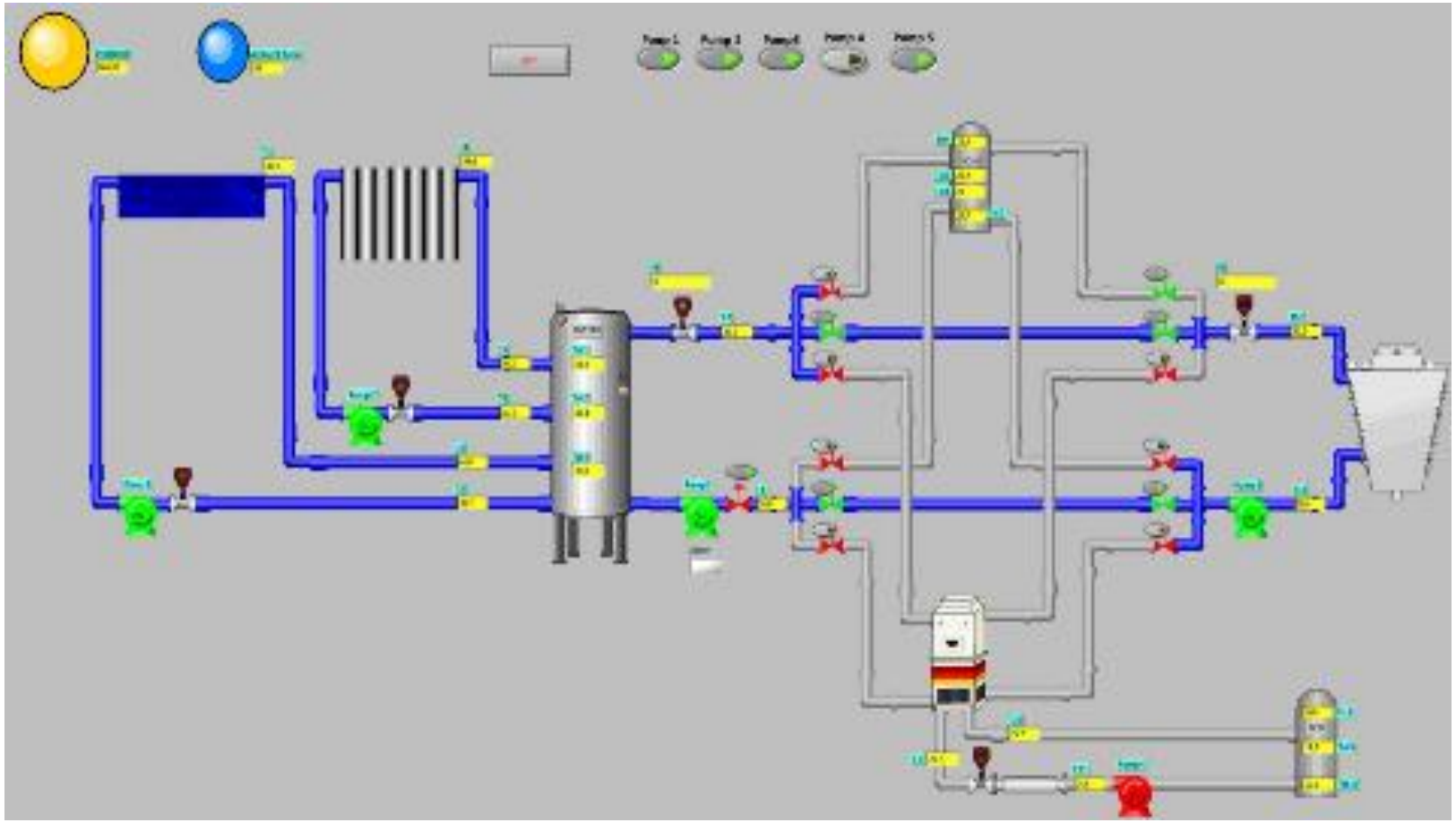
- *Thermal energy storage in the form of sensible heat in a water storage medium and in the form of latent heat*

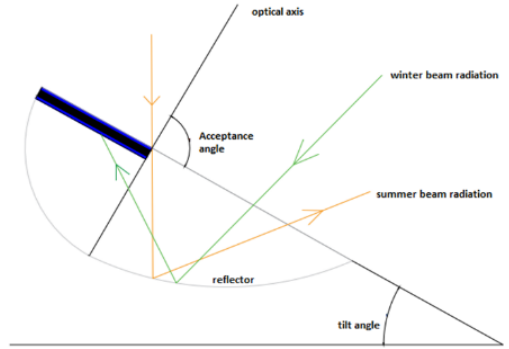
- *Production of cooling through a zeolite adsorption chiller*



Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Solar Cooling applications in Mechanical Engineering School





Building a Sustainable Campus: A Pathway to a Greener Future:

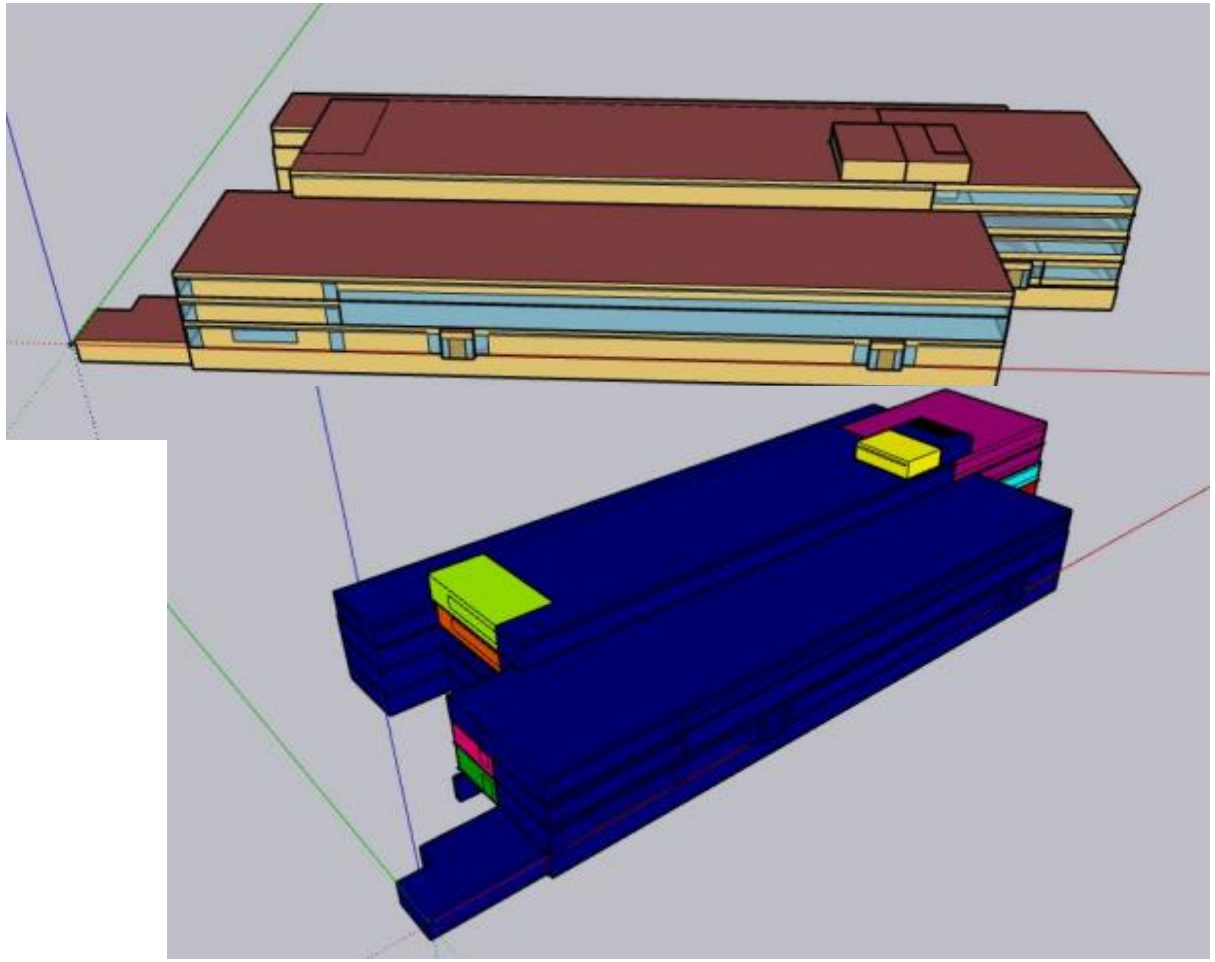
II. Energy Efficiency: Solar Cooling applications in Mechanical Engineering School

Dehumidification device with liquid desiccant material

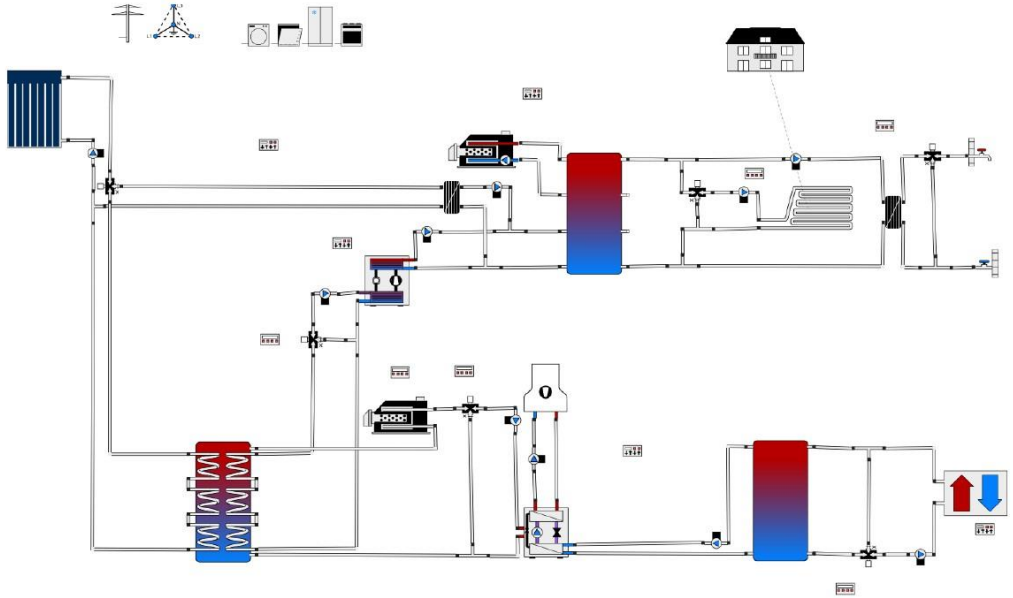
The experimental setup consists of a non-adiabatic dehumidifier and a regenerator with a plate heat exchanger
The term non-adiabatic is used to indicate that there is an exchange of energy between this arrangement and the surroundings.
There is thermal interaction with cold water coming from a cooling tower and introduced into the dehumidifier through a plate heat exchanger.
Characteristics
Rated power 5 kW
Thermal efficiency COP=0.5
Adsorbent LiCl
Hot water inlet temperature 55oC
Measuring Systems Temperature and pressure sensors

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Efficiency refurbishment of Campus Buildings according to National Standards



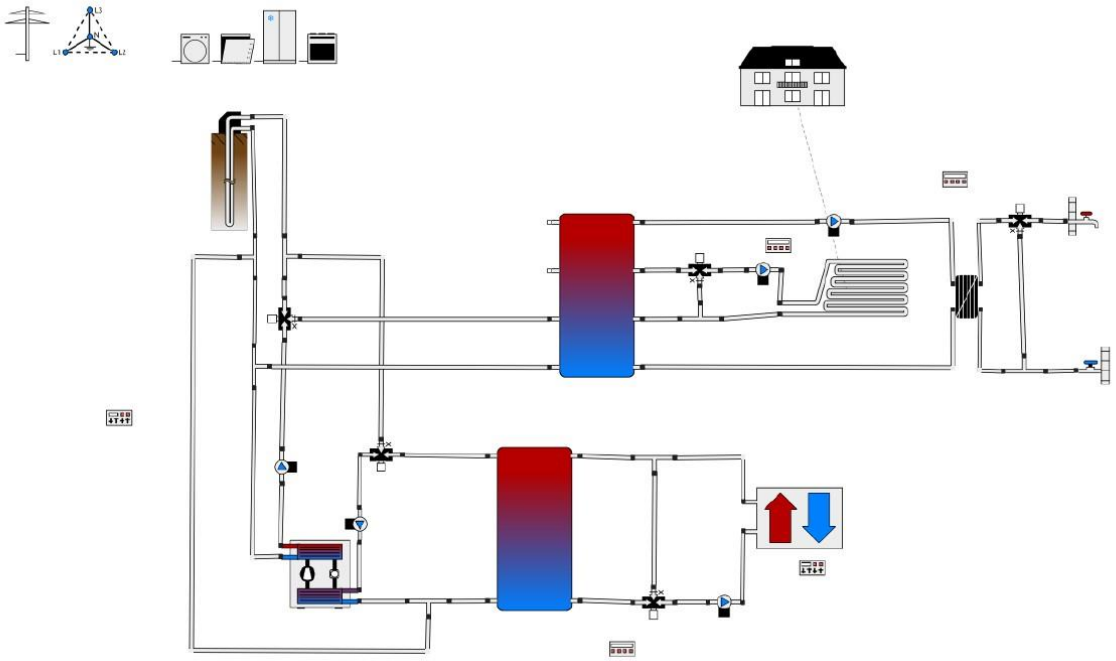
Hybrid Cooling System with Ice Storage



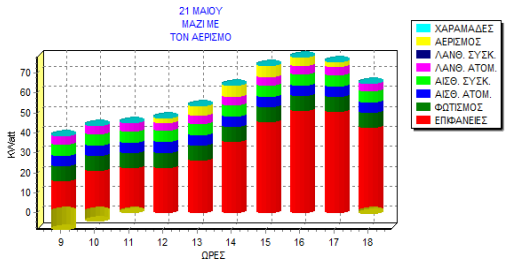
Building a Sustainable Campus: A Pathway to a Greener Future:

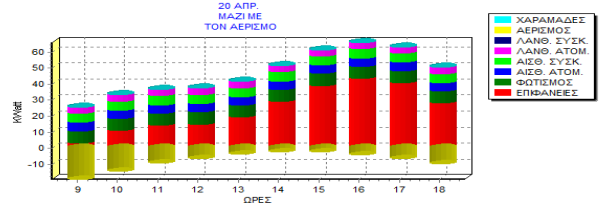
II. Energy Efficiency: Energy Efficiency refurbishment of Campus Buildings according to National Standards

Geothermal Heat System



PVs on the roof of ANYM





Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy analysis of NTUA Campus Buildings according to National Standards

New Buildings of Electrical Engineering School

	Heating	Cooling	Economizer	Water production system	Photovoltaic panels	Other interventions
Existing building	ASHRAE 90.1-2010 minimum efficiency Heat Pump (COP=3.2)	ASHRAE 90.1-2010 minimum efficiency Heat Pump (EER=9.5)	70F	Eff=0.57	-	-
Scenario 1	ASHRAE 90.1-2010 minimum efficiency Heat Pump (COP=3.2)	ASHRAE 90.1-2010 minimum efficiency Heat Pump (EER=9.5)	70F	Eff=0.57	Cover 60% of the roof (18.6% efficiency)	Strengthening th roof's thermal insulation with 1 cm of heat-insulating materi
Scenario 2	High-Efficiency Heat Pump (HSPF=9.6)	High-Efficiency Heat Pump (SEER=17.4)	70F	Eff=0.57	Cover 60% of the roof (16% efficiency)	-
Scenario 3	High-Efficiency VAV, Underfloor Air Distribution, Gas Boiler (Eff=0.95)	High-Efficiency VAV, Underfloor Air Distribution, Chiller (COP=7.5)	70F	Eff=0.57	Cover 75% of the roof (20.4% efficiency)	-
Scenario 4	ASHRAE Terminal Package Heat Pump (COP=4.5)	ASHRAE Terminal Package Heat Pump (EER=11.9)	70F	Eff=0.57	Cover 60% of the roof (18.6% efficiency)	-

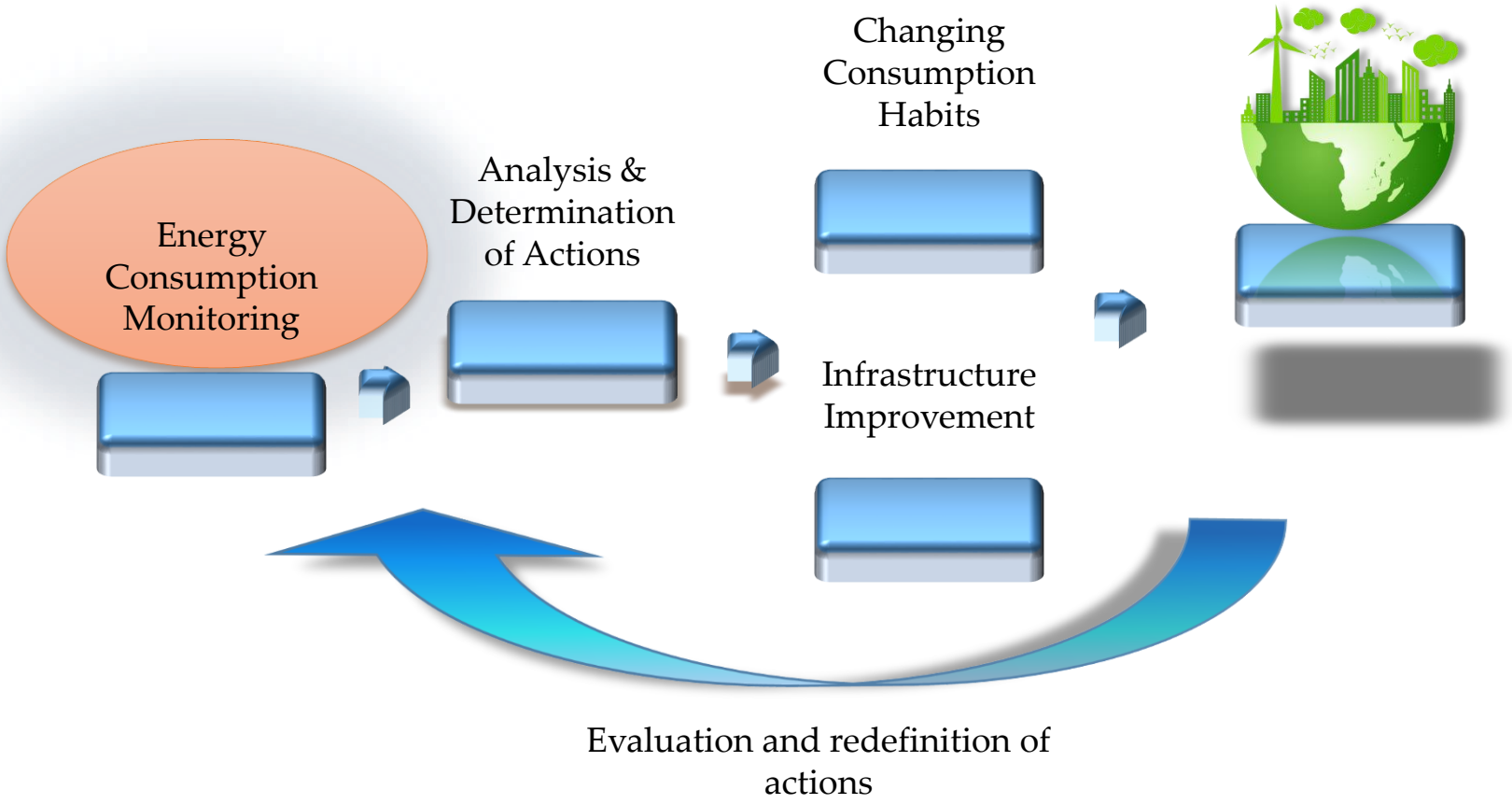
EULIST European Universities Linking Society and Technology

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

Objective



Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS
Building a Sustainable Campus: A Pathway to a Greener Future:
II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

Current situation

- 65 buildings, 1000 acres, 240,000 m2
- 36 M/S 20/0.4 KV
- Installed analogue voltage & current instruments at the 36 arrival points of the GPHTs
- Data network points at a distance of 20-50m except from the MT arrival building, where it is 500m away.

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS
Building a Sustainable Campus: A Pathway to a Greener Future:
II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

- Measurement of Electrical Quantities - 49 CT measurement points & 1 MT measurement point
- Phase Voltage & Current, per phase Active & Reactive Power, Total Active & Reactive Power, Total SI, Total Energy
- Measurement of room conditions (T(°C), H (%), E(Lux)) - 12 points
- Automatic Recordings of the Energy & Power of each energy meter
- Automatic Recordings of room conditions
- Ability to monitor the system in real time
- Display of the consumptions on a screen where the consumptions of the buildings can be seen in real time

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS
Building a Sustainable Campus: A Pathway to a Greener Future:
II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

System definition

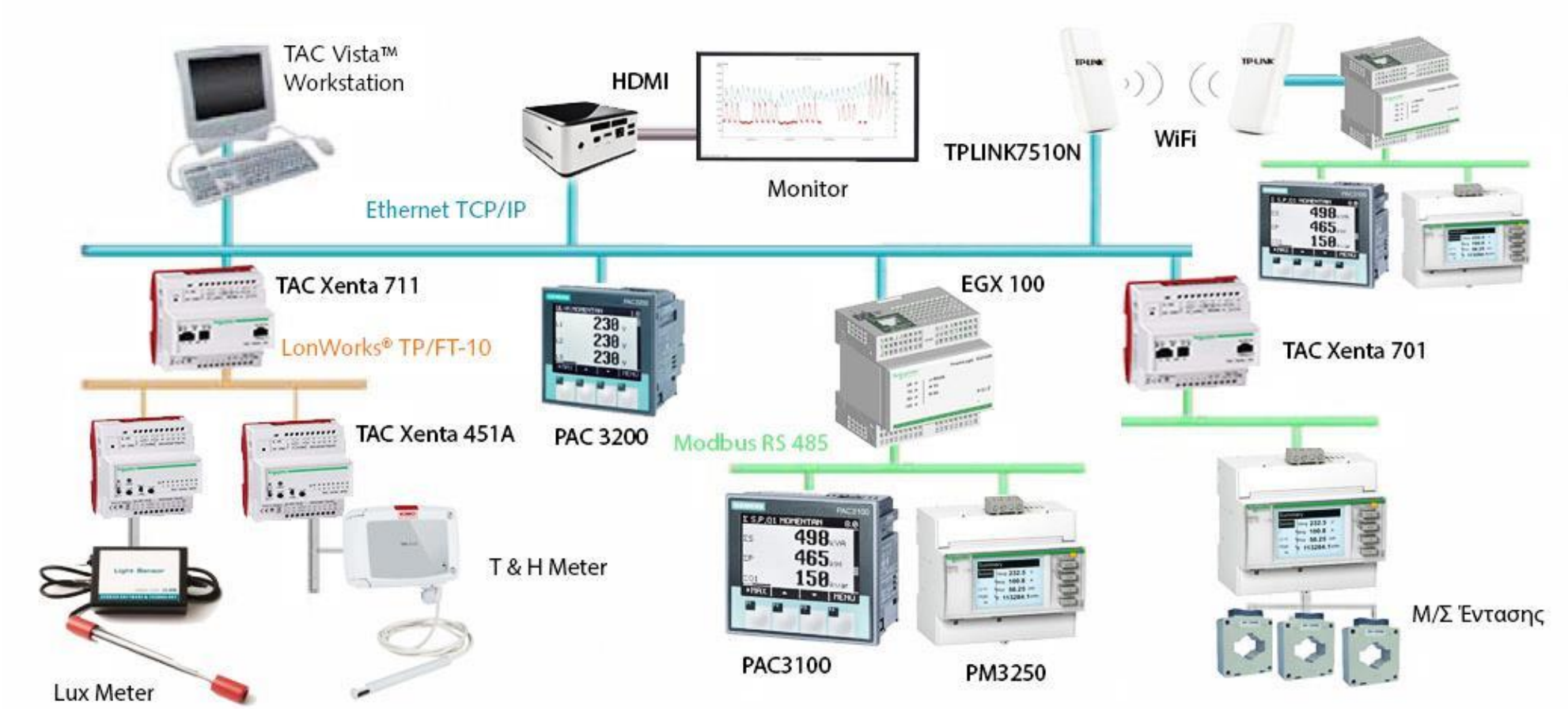
- Measurements required
- Meters
- Communication with meters
- Conversion of measurements
- Record Measurements
- View of Measurements

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

System Topology

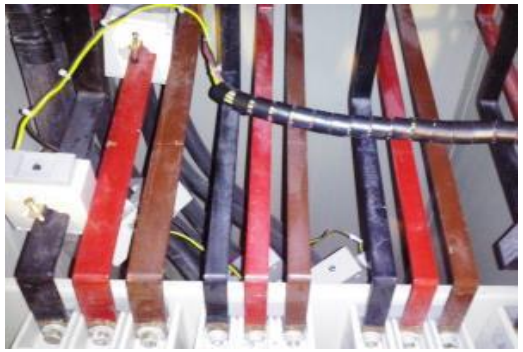


Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

Installation of the System



Voltage Transformer installation

Door counter installed PAC3100

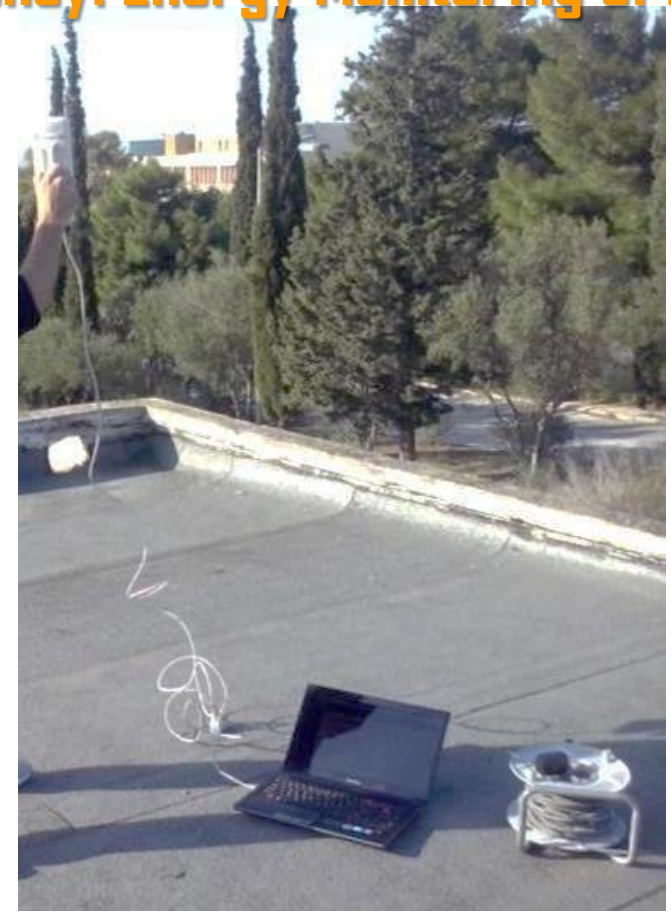
Measurements on departures of other Low Voltage Panels

Installation of rail meters on an external wall panel

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings



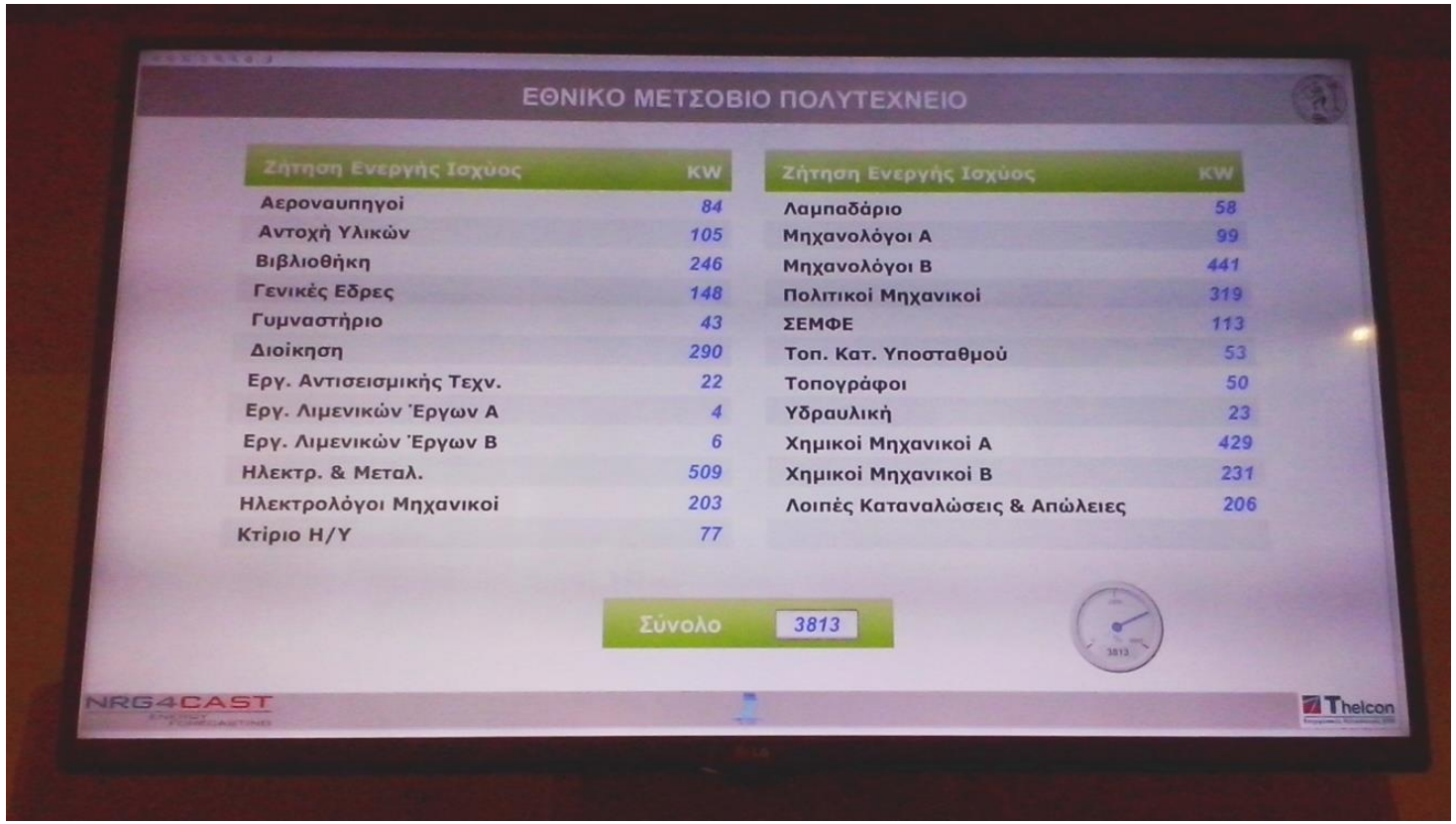
Xenta 711 Controller & I/O Modules

Xenta 701 controller

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings



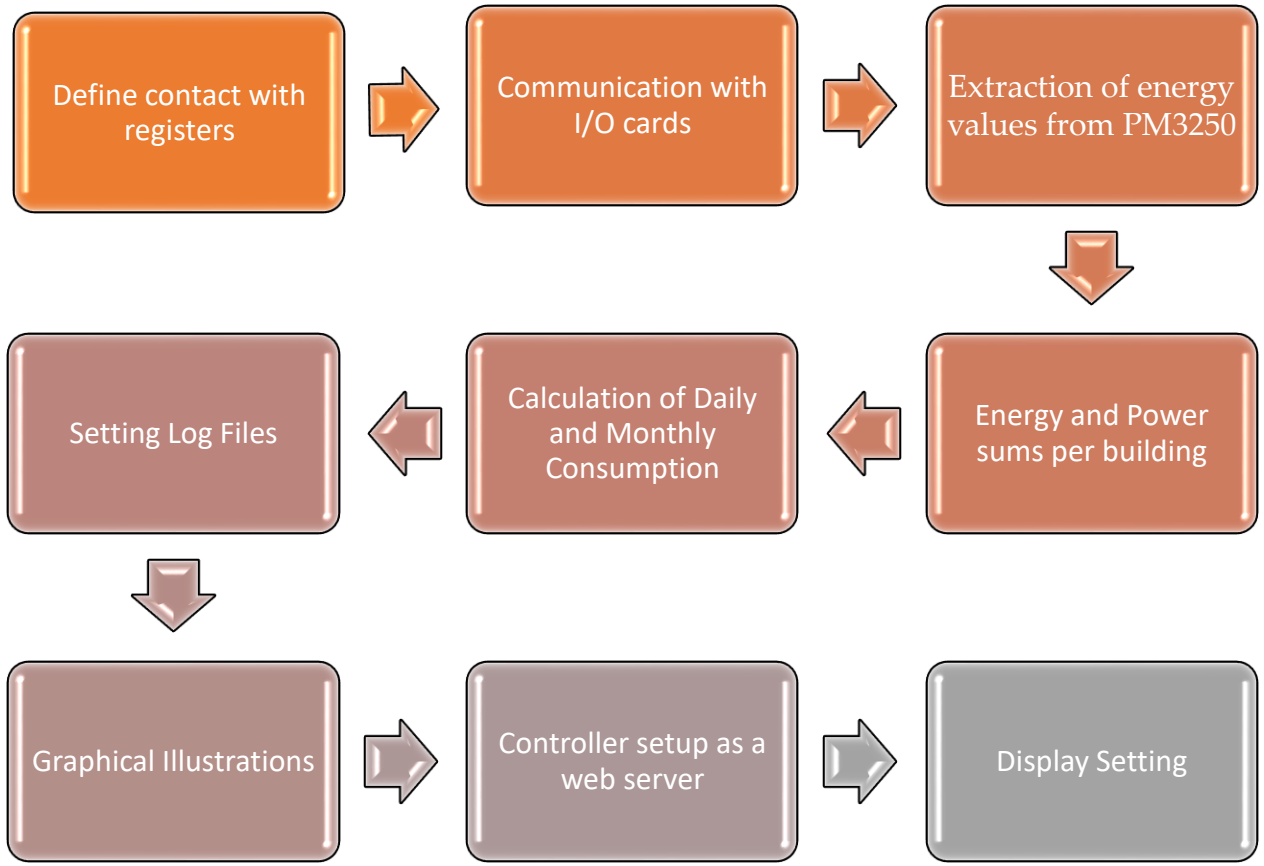
School building consumption display screen

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

System Setup

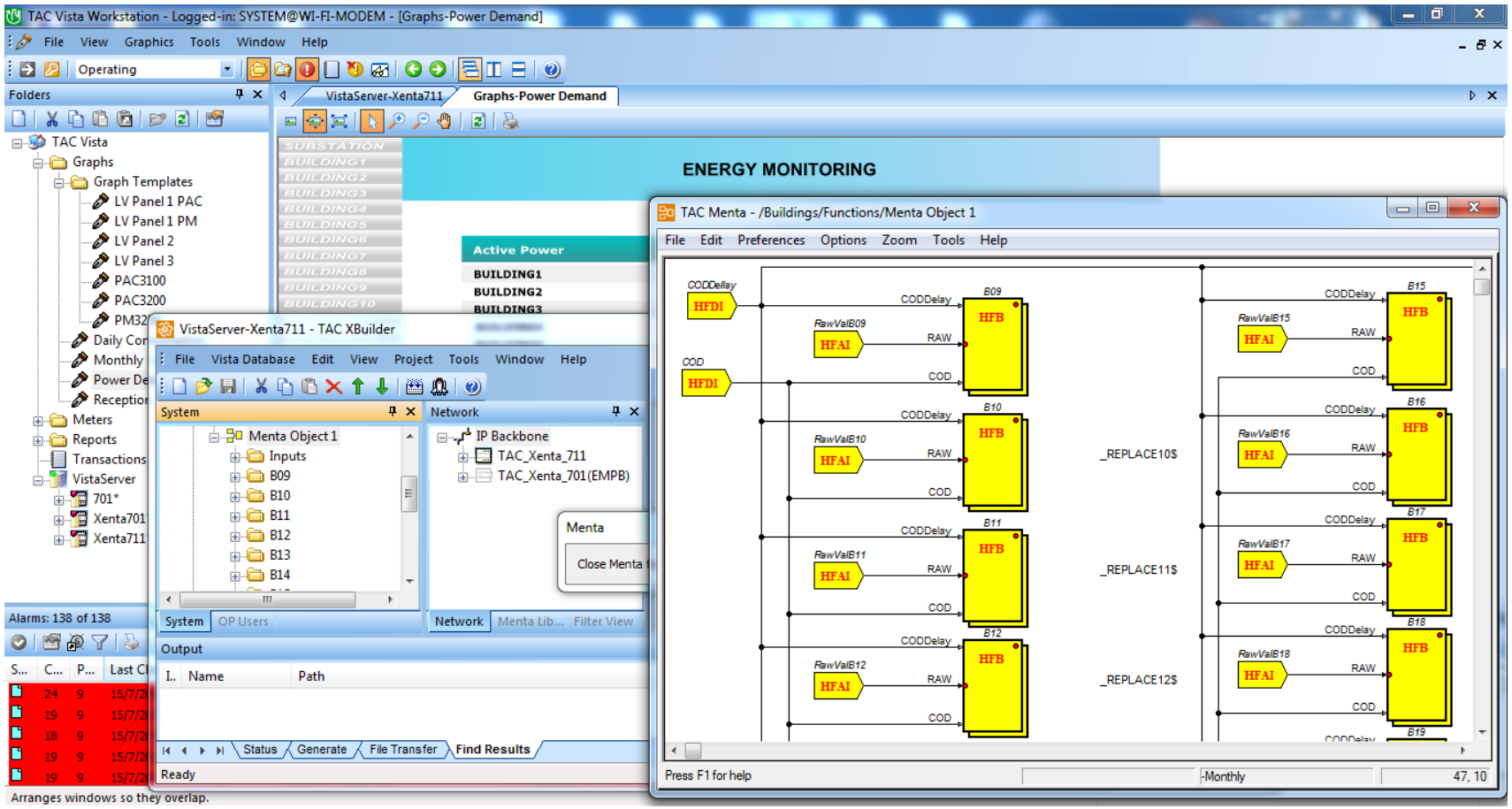


Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

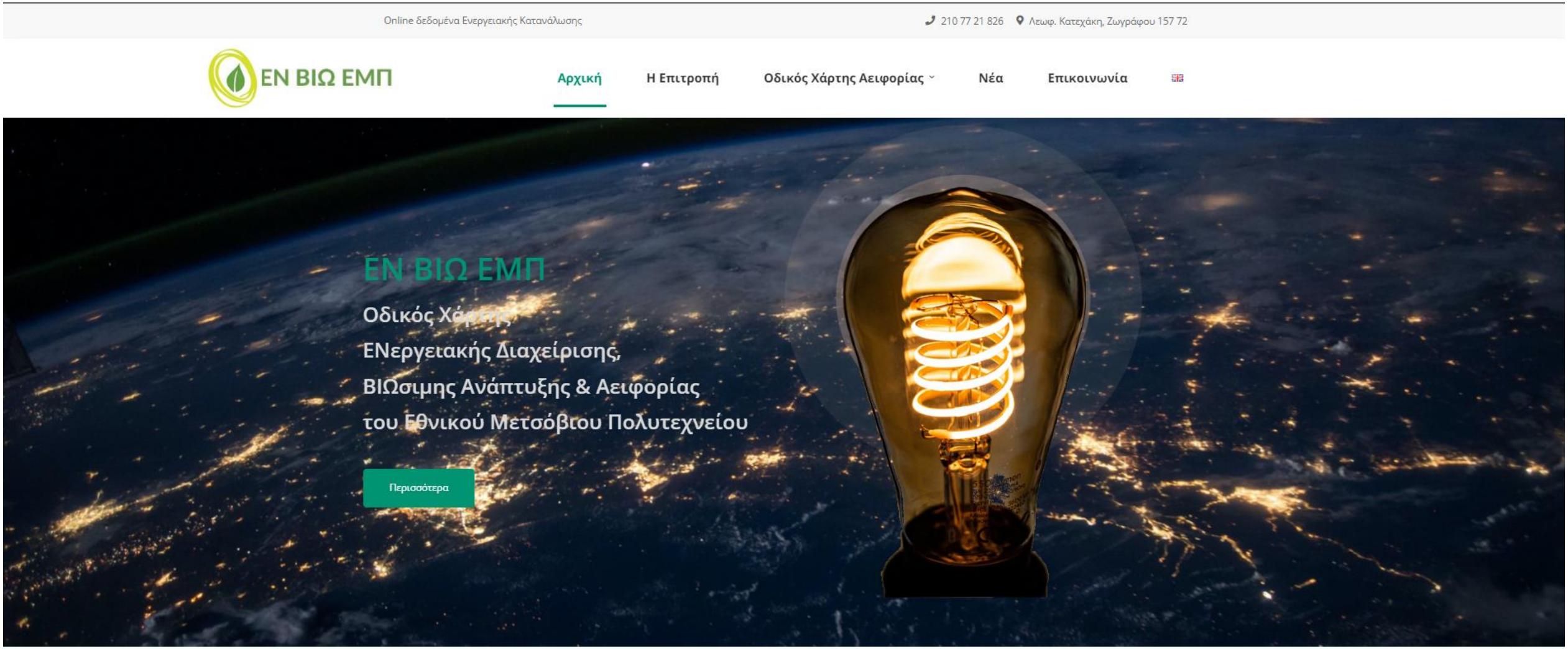
Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

System Management Environment



ENERGY MANAGEMENT ROADMAP WEBSITE, OF SUSTAINABLE DEVELOPMENT AND SUSTAINABILITY

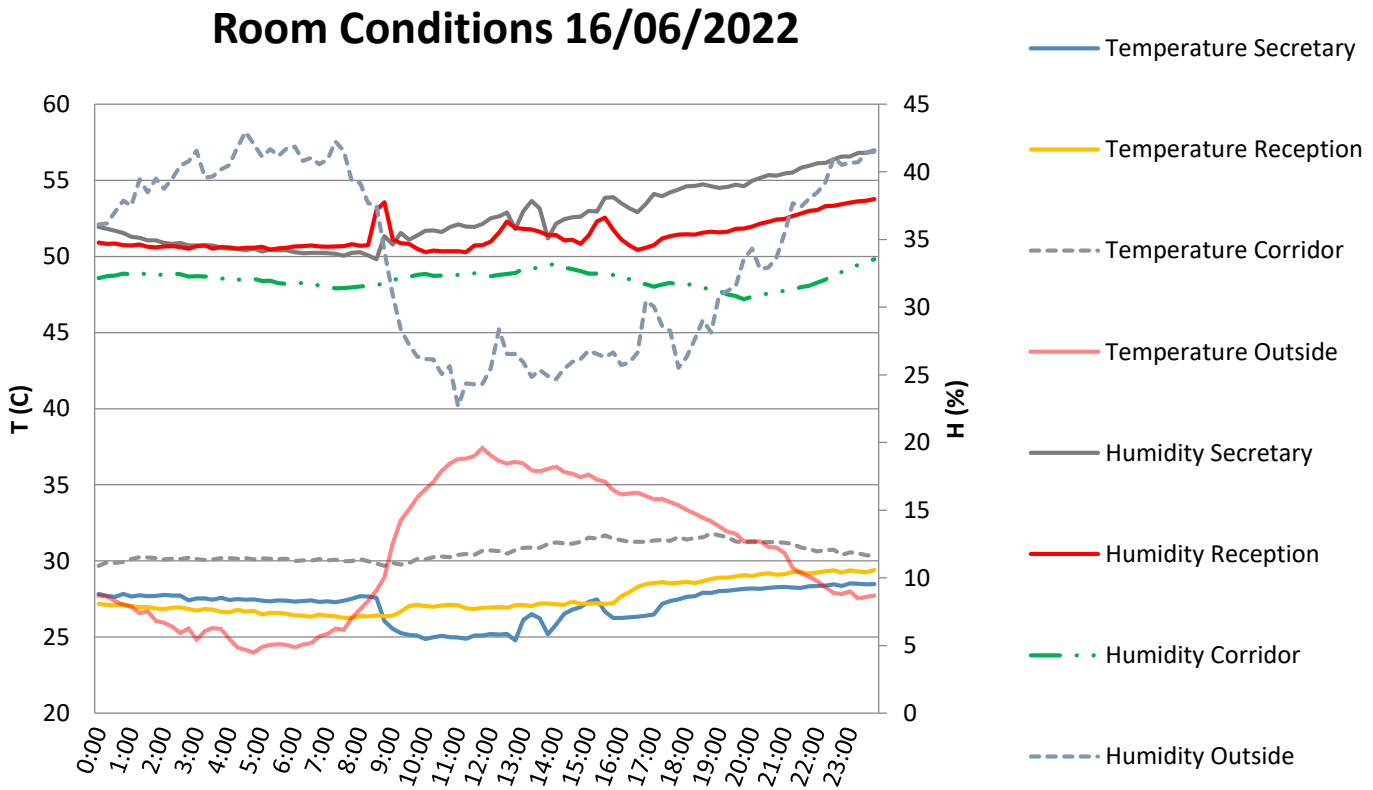


http://envio.ntua.gr/v1/

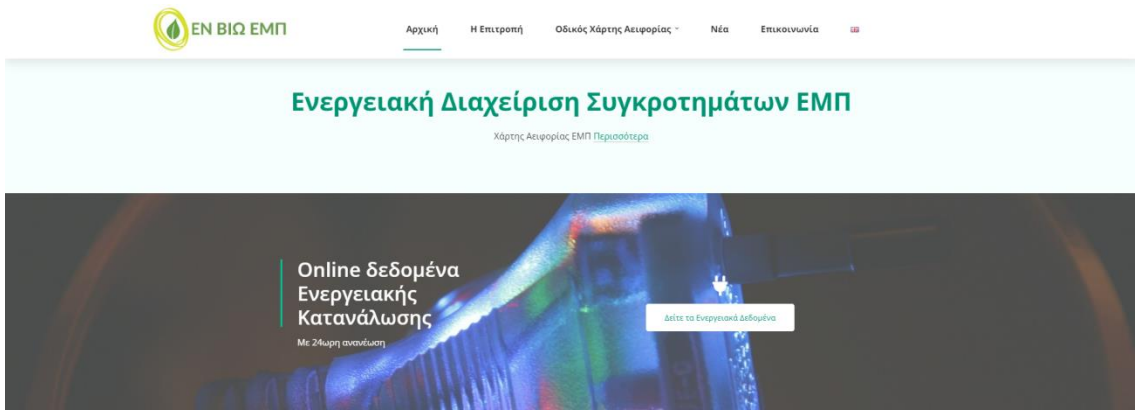
Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

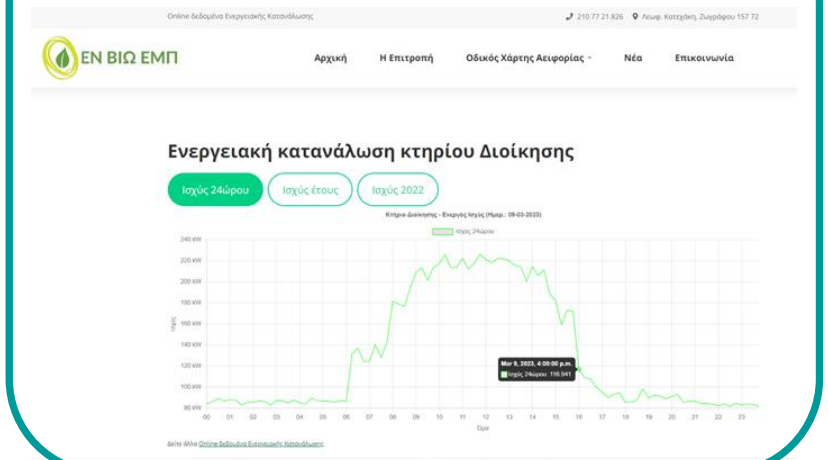


Installed Energy Management System

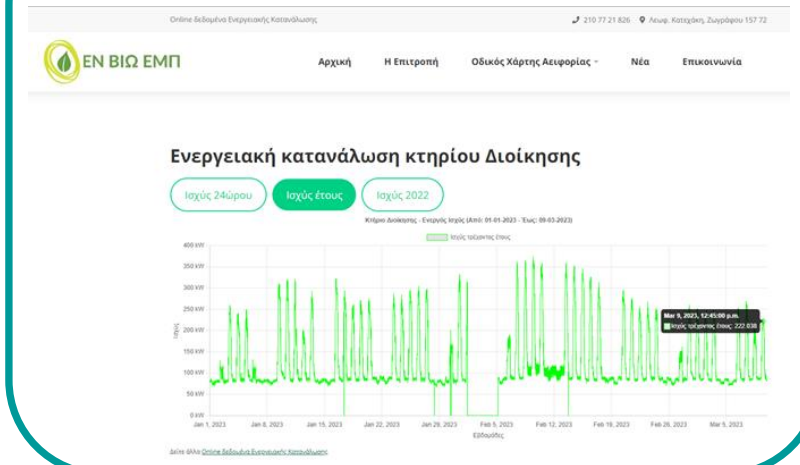


- Utilization-Installation of a network of 70 electricity meters in the buildings of the Zografou and Patisia complex
- Installation of meters to determine the electricity produced by the photovoltaic installations of the Library and the School of Chemical Engineering NTUA

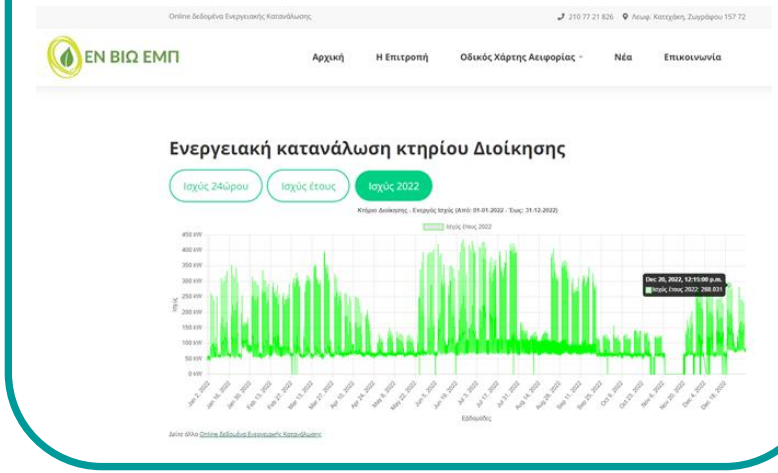
Presentation of measurements on a daily basis



Presentation of current year measurements



Presentation of previous year's measurements

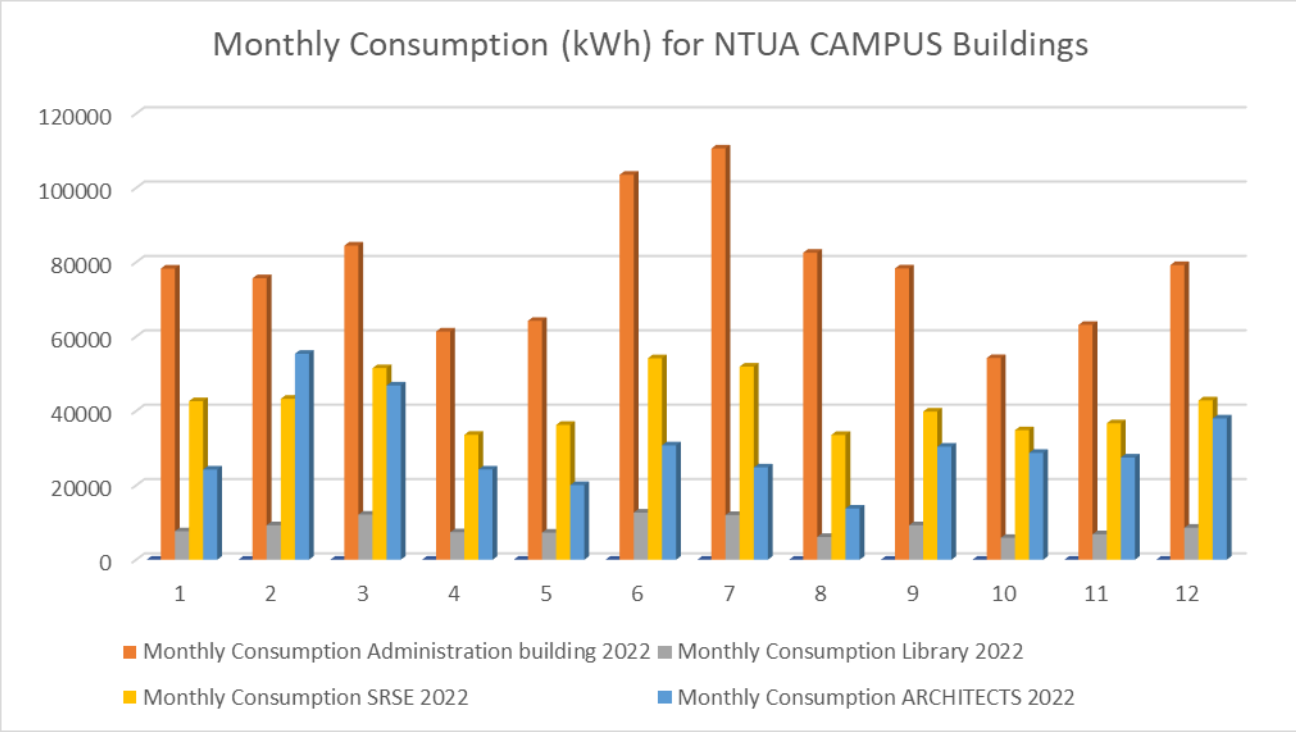


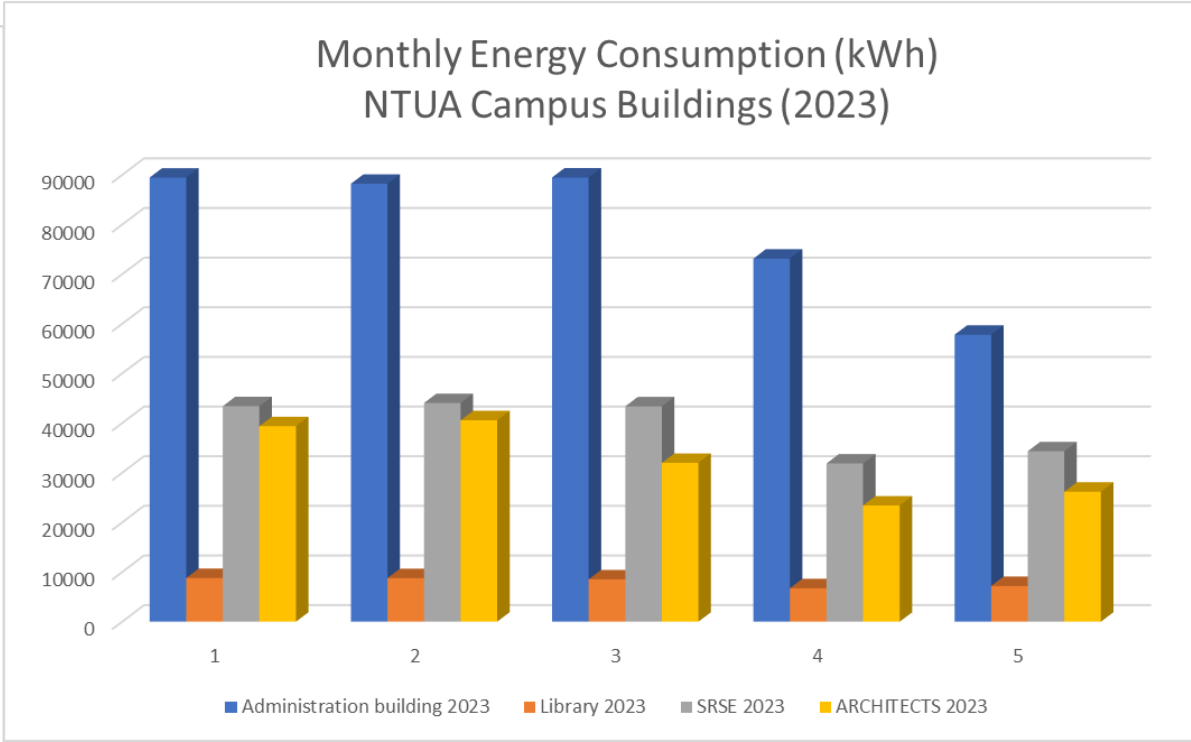
http://envio.ntua.gr/v1/case_study/online-dedomena-energeiakis-katanalosis/

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings

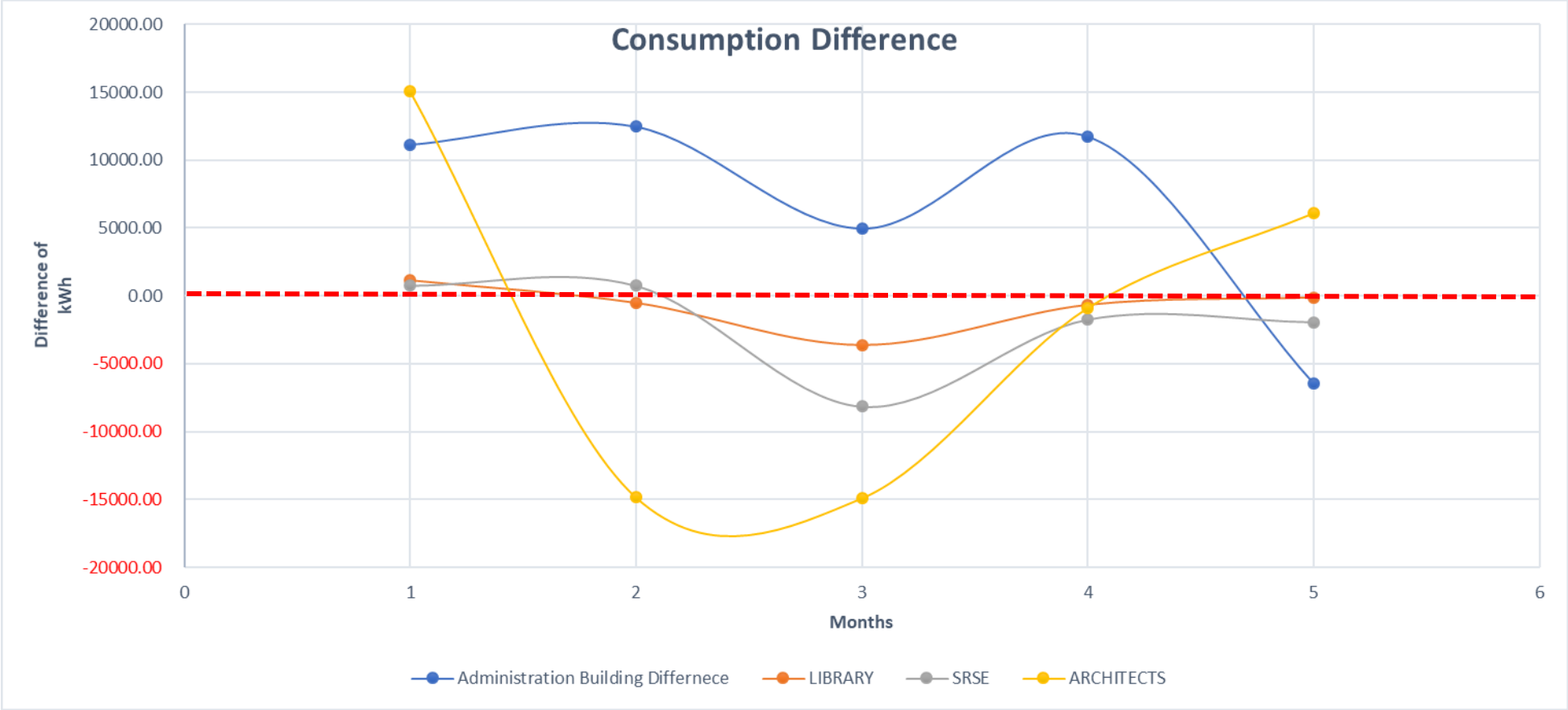




Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

II. Energy Efficiency: Energy Monitoring of NTUA Campus Buildings



MEASUREMENTS OF CLIMATE CHANGE PARAMETERS

NTUA – Zografou Campus

Ultraviolet-visible solar radiation

NTUA-DIONISOS

PM_{10}, $PM_{2.5}$, PM_1

Ultraviolet-visible solar radiation

NTUA-LAVRIO

Weather station+
PM_1, $PM_{2.5}$ PM_{10}

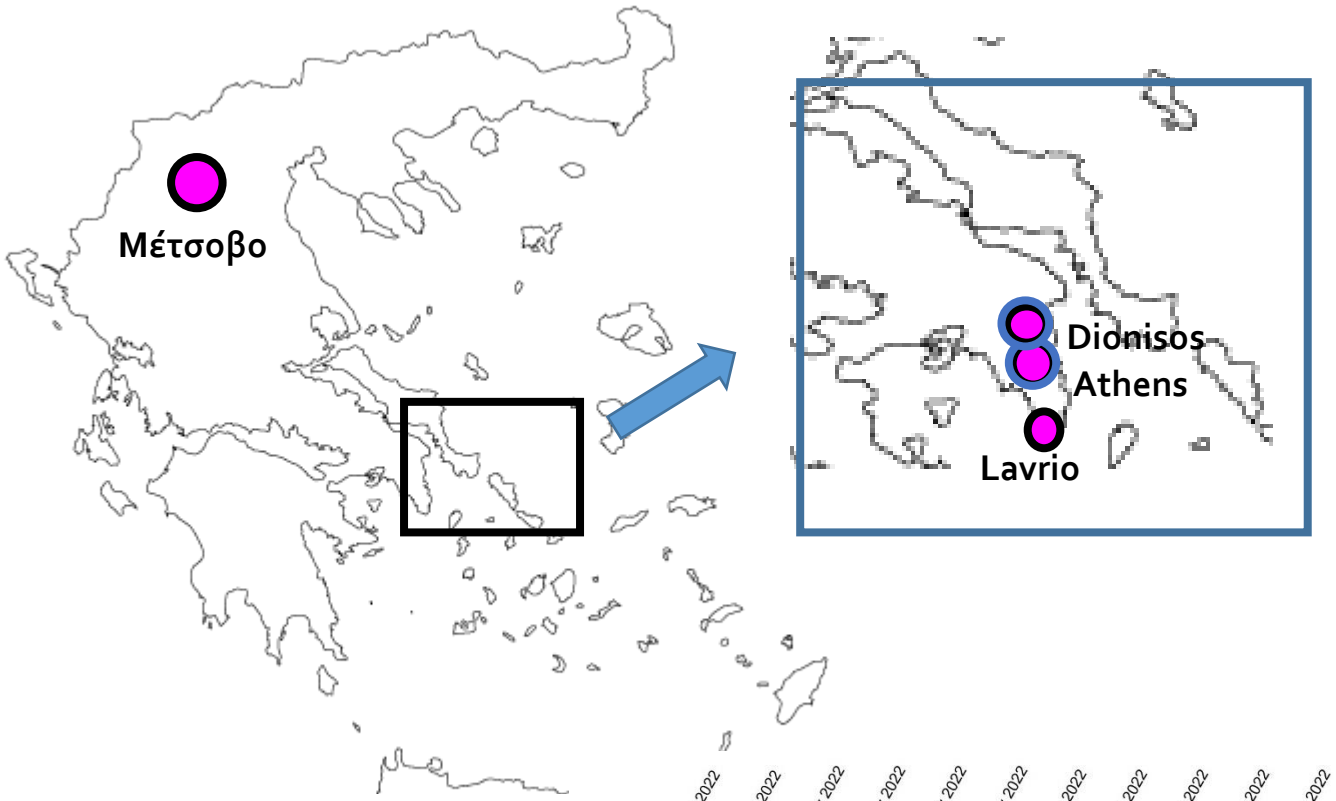
NTUA-METSOVO

PM_{10}, $PM_{2.5}$, PM_1

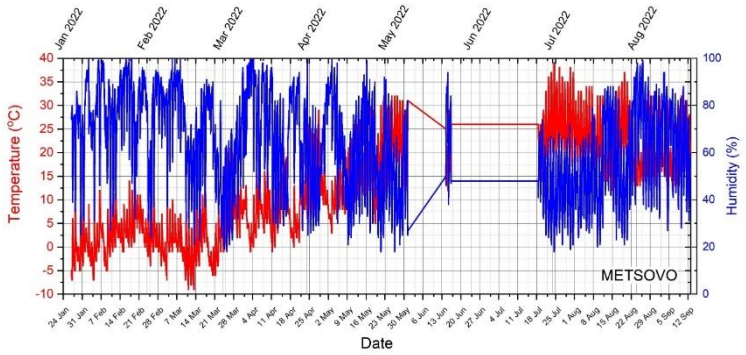
Weather station

Weather Station - Particulate Sensor

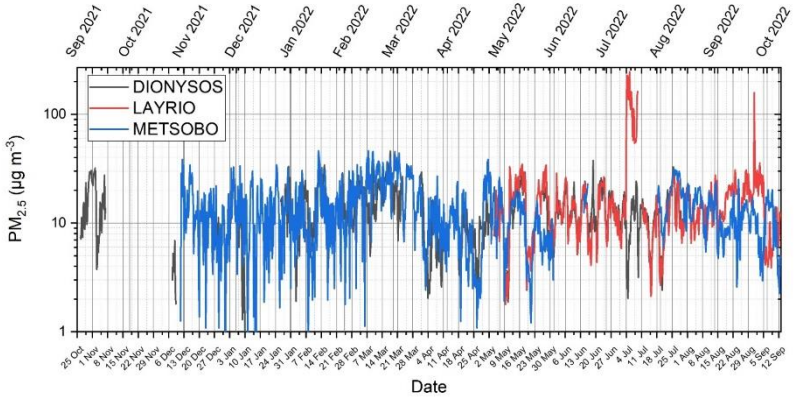
Weather Station - Particulate Meter - Solar UV Station



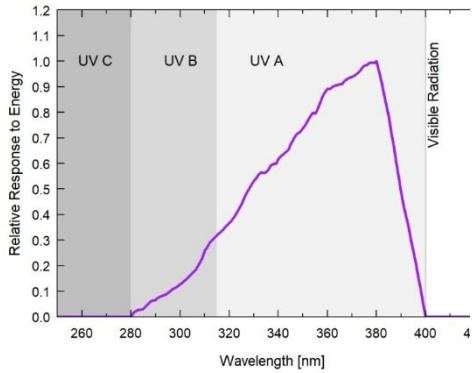
Meteorological data: (pressure, humidity, temperature, precipitation)

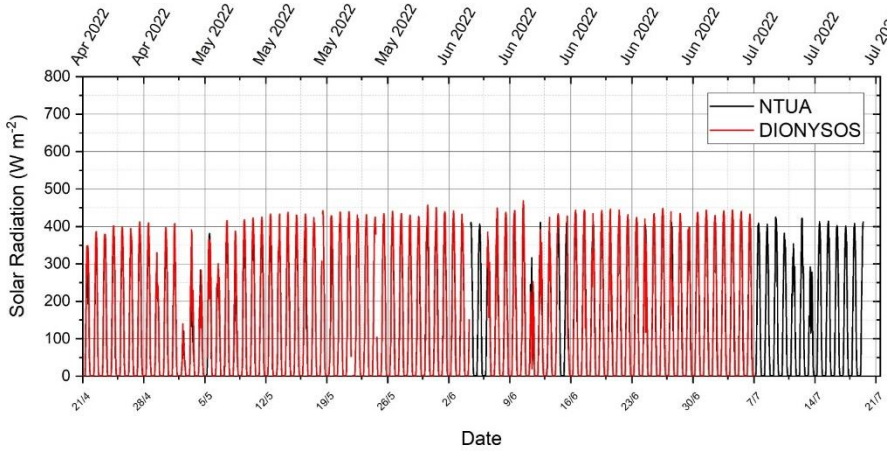


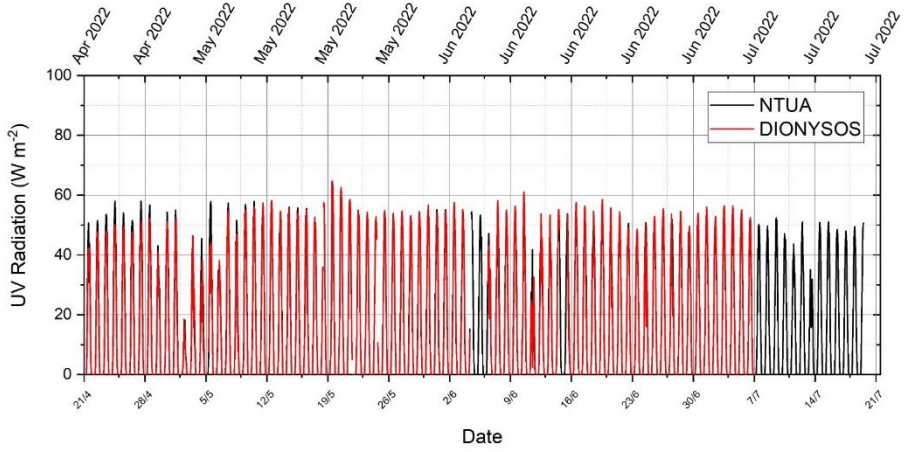
Particulate matter: ($PM_{1.0}$ $PM_{2.5}$ PM_{10})



Ultraviolet (UVB-UVA) & Visible Solar radiation:







Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Building a Sustainable Campus: A Pathway to a Greener Future:

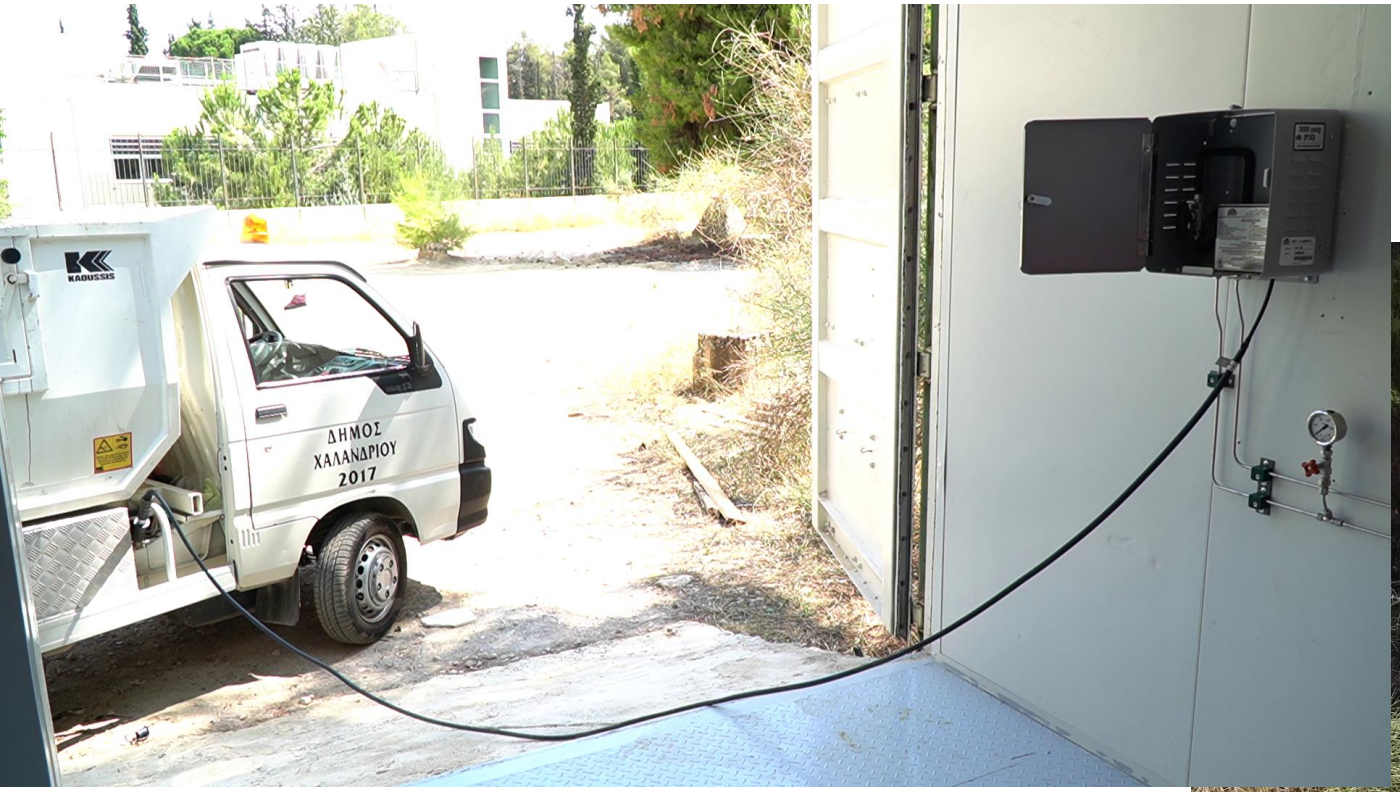
III. Waste Management and Recycling: ACTIONS

Pilot Biogas Production Unit in Chemical Engineering School

- Implementing a comprehensive recycling program.
- Encouraging composting for organic waste.
- Reducing paper usage through digital alternatives.
- Promoting the reuse and repair of materials.

Building a Sustainable Campus: A Pathway to a Greener Future:

III. Waste Management and Recycling:: Pilot Biogas Production Unit in Chemical Engineering School

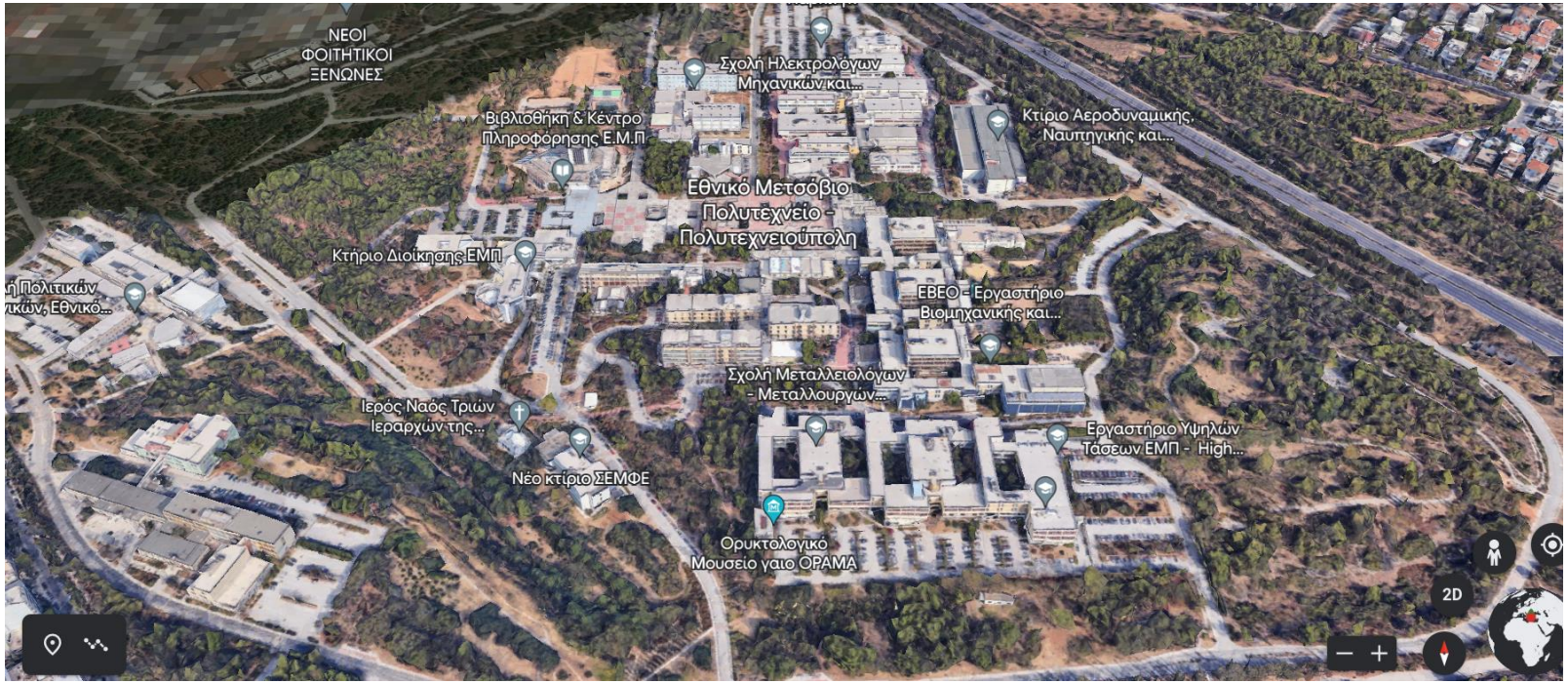


Building a Sustainable Campus: A Pathway to a Greener Future:

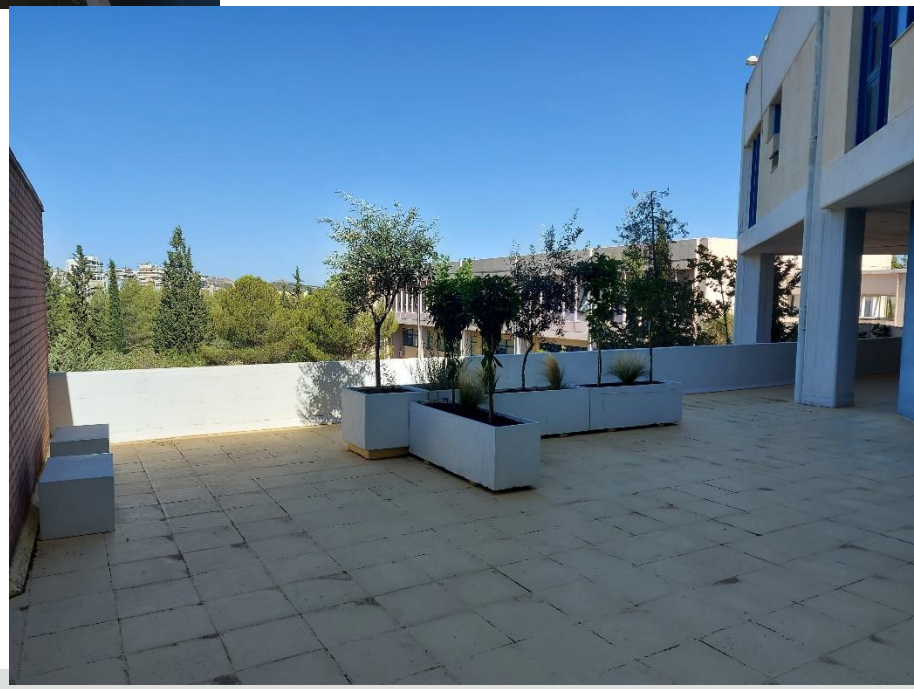
VI. Green Spaces and Biodiversity:

Creating a sustainable campus.

- Creating native plant gardens with aromatic Greek plants.
- Establishing wildlife habitats.
- Incorporating outdoor learning spaces.
- Creating walking pathways through medicinal and aromatic plants of Zografou Campus



Creation of green spaces in the Administration Building and the Financial Services Building



Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

PROJECT 'S STEPS

Thank you for your attention!

Prof. Irene P. Koronaki
Director of Applied Thermodynamics Lab
URL: http://thermolab.mech.ntua.gr/v2/