EULiST Blended Intensive Program

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

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Professor

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Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Introduction:

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

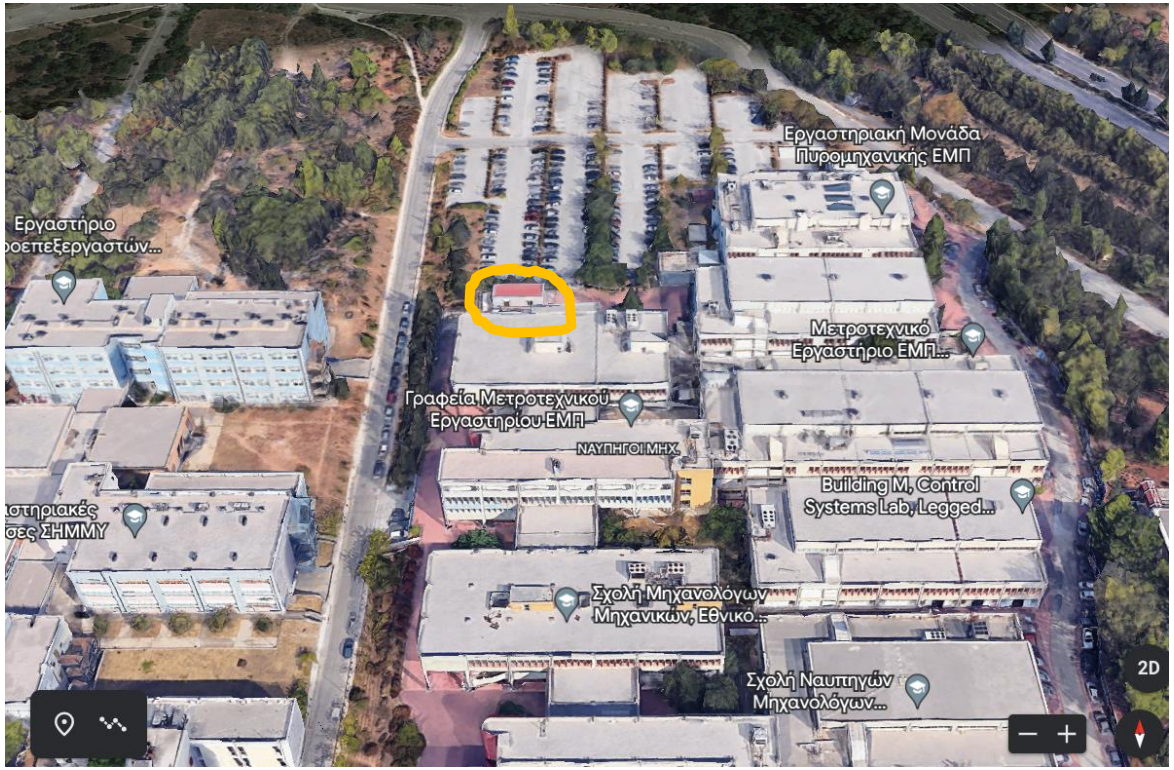
ASHRAE 2021
INTERNATIONAL DESIGN COMPETITION
INTEGRATED SUSTAINABLE BUILDING DESIGN CATEGORY
SECOND PRIZE FOR NTUA

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

NTUA Premises

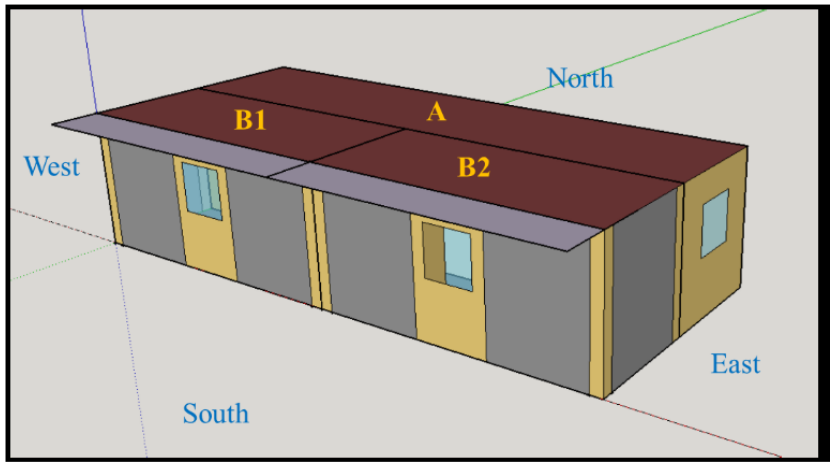


ZEB LIVING LAB

Monitoring clean energy in the EULiST campuses – ZOGRAFOU NTUA CAMPUS

Project title: Eco-Friendly Sustainable Campus

A new Prototype building model designed and constructed in the School of Mechanical Engineering of NTUA Zografou Campus with the following criteria:



A) nZEB and ZEB (Nearly Zero Energy Building)

B) Possibility of alternating masonry and glazing

C) Easy switching of thermal and electrical energy production systems.

D) Monitoring and controlling of building's passive and active operational systems.

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

→ Use of a BEM software like EnergyPlus Building Energy Modelling

- Use of a BEM software like EnergyPlus to analyze and optimize the energy design of a prototype building
- Division into four groups

OFFICES

A
Mehar
Gera
Renata
Tomei
Papingiotis
Mylona

LIBRARY

B
Sadiqa
Mohammadi
Shlumbom
Tauschke
Los
Giannitsis
Tsala

RESIDENTIAL

C
Patel
Gudabova
Chripkova
Illesova
Mitsialis
Antoneas

CONFERENCE ROOM

D
Barbanov
Shlarmann
Giusti
Papamichail
Theodoropoulos

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

PROJECT 'S STEPS

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus → STEP 1: Software Setup

- Download and install Openstudio software on your computer. (Version 1.6) https://openstudiocoalition.org/getting_started/getting_started/
- You can find the software and documentation on the official EnergyPlus website. https://energyplus.net/
- Familiarize yourself with the Openstudio interface and the basic concepts of building energy simulation.
- Energy plus: https://www.youtube.com/watch?v=e-4xIRUmQVg&list=PL83CB71B24D2650E9&ab_channel=GARDAnalytics
- Openstudio:
- https://www.youtube.com/watch?v=w-yVg0vcQaA&list=PLRW2KXkdSVUdY2iQ6yjohNT5E5EILVIhU&ab_channel=HelixEnergyPartnersLLC

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus → STEP 1: Software Setup

- Use of a Base Case model building
- The base case building is inside the NTUA Campus
- Every team will design the base case building for a different intended use:
  - Team A – Office
  - Team B – Library
  - Team C – Residential
  - Team D – Conference Room
- The Base Case building will be simulated in different climate zones and with multiple Constructions, HVAC systems, RES

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

STEP 2: Prototype Building Setup - Simulation run

a. Open the given model in openstudio.

b. Specify the weather data for the location where the PB is situated. You can obtain weather data from enrgyplus site (https://energyplus.net/weather) or reputable sources such as https://climate.onebuilding.org/. Both Annual weather data and design days should be entered.

c. Determine the construction materials, insulation levels, and glazing characteristics for different building elements (walls, roof, windows, doors, etc.)

d. Configure the simulation settings, such as the simulation period, time step, and output variables.

e. Input the occupancy schedule, lighting loads, and other internal gains

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

STEP 2: Prototype Building Setup - Simulation run

Climatic Design Conditions – Climate Zones

- Climatic Design Data play a crucial role for our model simulation
- Ashrae has divided the world map into 8 climate zones
- For our Project we will use 4 cities from different climate zones
- Main purpose is to understand and compare how the climate affects the building's energy consumption

Country	City	Ashrae Climate Zone*
Greece	Athens	3A
France	Paris	4A
Germany	Hamburg	5A
Sweden	Stockholm	6A

* As it is described in Ashrae's Addenda 169-2020

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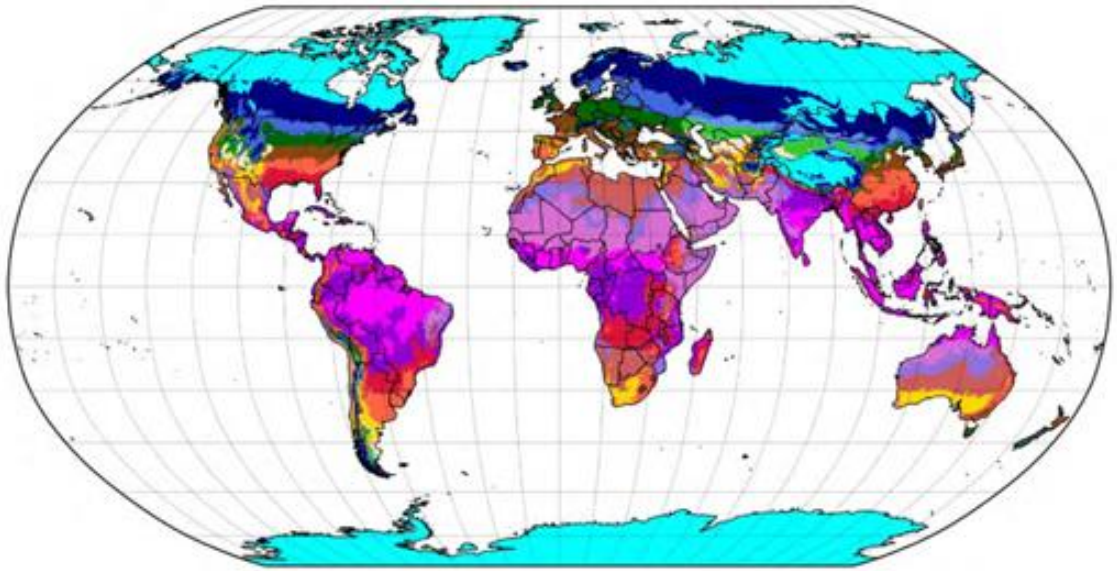
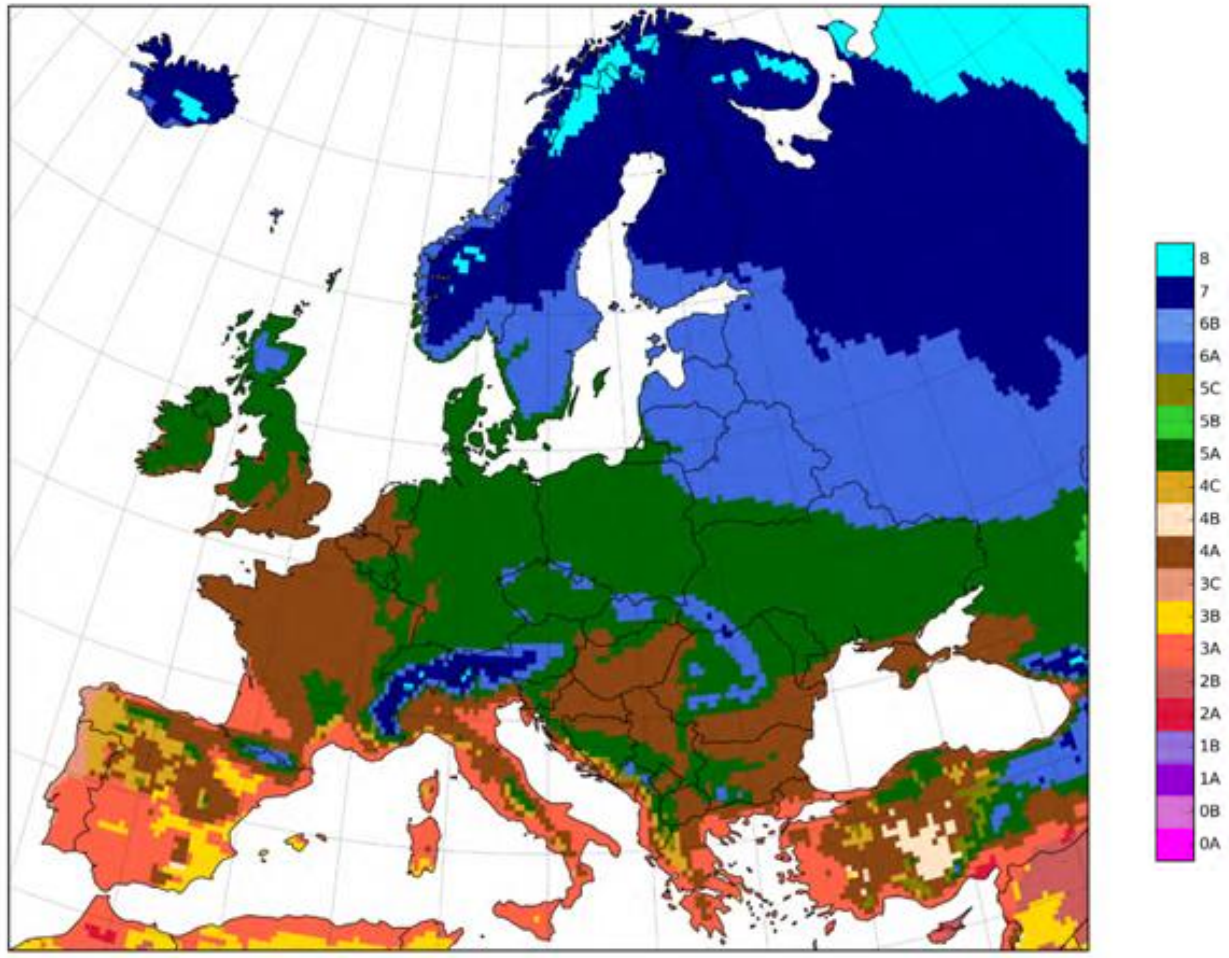
Climatic Design Conditions – Climate Zones





* Pictures are taken from Ashrae's Addenda 169-2020

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

STEP 2: Prototype Building Setup - Simulation run

Building Envelope

- Define the constructions of walls, roofs, floors and windows of the building
- During the Project you will define the materials of each construction and define the total U-value of each construction
- Validate the total U-values for each climate zone and building's intended use according to the compliance values from Ashrae's Standard 189.1
- For walls, roofs and floors you will need the total U-value
- For windows you will need the total U-value and the Solar Heat Gain Coefficient (SHGC)

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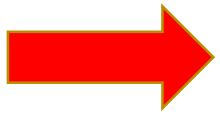
Project title: Eco-Friendly Sustainable Campus



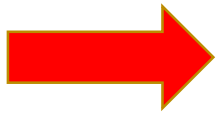
STEP 2: Prototype Building Setup - Simulation run

Internal Loads & Schedules

- The operation of the building is designed in the loads tabs
- The total amount of occupants, the lights, the electrical equipment are the main internal heat gain loads that must be designed
- Depending on the intended use, each team will have to set different values for the internal loads
- The values will be collected from Ashrae's Fundamentals Handbook
- On the schedules tab you will create the operational schedules for the simulation
- The schedules connect every parameter of the model with time and how they differentiate throughout the year.

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus



STEP 2: Prototype Building Setup - Simulation run

Thermal Zones

- Division of building to smaller spaces of multiple rooms with similar thermal properties
- Thermal Properties considered:
  - Orientation of the space
  - Occupancy profile of the space
  - Internal Loads of the space
  - Desired Temperature Setpoint
- It is necessary to define two thermostats for every thermal zone, one for the Heating Period and one for the Cooling

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

STEP 2: Prototype Building Setup - Simulation run

Simulation run

1. Run the simulation with Ideal loads.
2. Review the simulation results
3. Define the HVAC (Heating, Ventilation, and Air Conditioning) system parameters, including equipment types, efficiency ratings, and control strategies
4. Re-run the model with the HVAC system
5. Review the energy consumption per fuel
6. Monitor internal conditions (Temperature, Humidity) and possible unmet load hours Input

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

STEP 3: Energy Optimization

STEP 3: Energy Optimization:

a. Implement energy-saving strategies to improve the PB's energy efficiency. Consider options (for example increased insulation, efficient HVAC equipment, Heat Pumps with VAV, Control strategies for the HVAC system (e.g. outdoor air reset, Demand control ventilation, economizer), Daylight control with sensors, BIPVs etc.)

b. Modify the relevant parameters in the Openstudio model based on your chosen strategies.

c. Explore involved costs with each scenario for a 25 year life cycle

d. Rerun the simulation to evaluate the impact of the energy-saving strategies on the PB's energy performance. d. Compare and analyze the simulation results before and after implementing the energy-saving strategies.

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus

STEP 3: Simulation scenarios

Simulation Scenarios

1. Ideal Loads (The need of Cooling and Heating)
2. Orientation change of the building
3. VRF + DOAS system
4. VAV system
5. Application of Economizer, Demand Control Ventilation and Heat Exchanger on every system
6. Ground Source Heat Pump + DOAS Systems
7. Integration of PVs
8. Daylight Control of interior lighting
9. LED Lighting systems

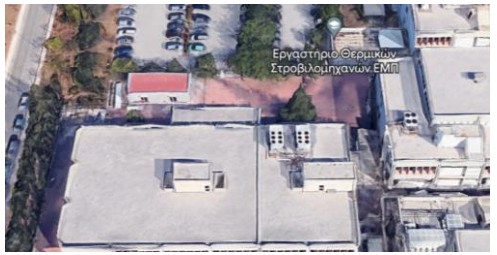
Construction scenarios

HVAC scenarios

RES scenarios

LINGHTING scenarios

Monitoring clean energy in the EULiST campuses



Project title: Eco-Friendly Sustainable Campus - STEP 3: Simulation scenarios

Simulation Scenarios

Orientation change of the building

South

North

East

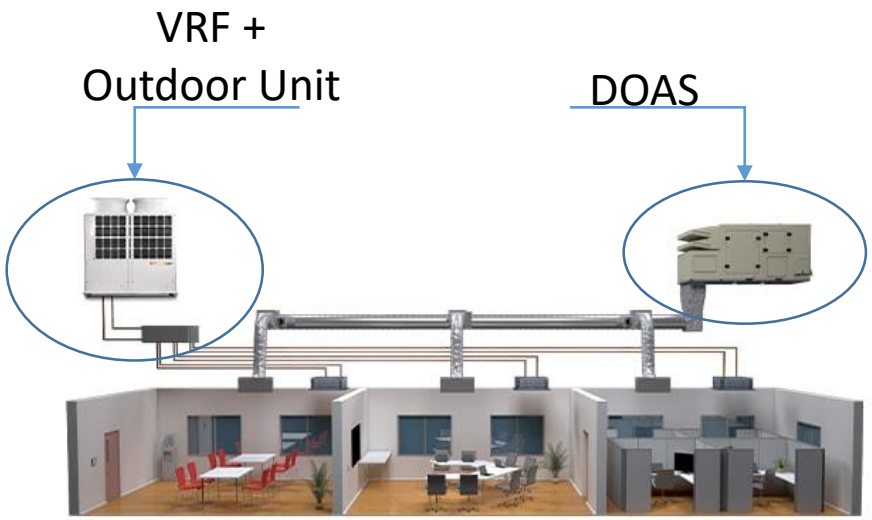
West

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus → STEP 3: Simulation Scenarios

Simulation Scenarios Variable Refrigerant Flow System (VRF) + Dedicated Outdoor Air System (DOAS)

- One of the most common application to achieve the desirable temperature and Outdoor Air supply rate
- The VRF system uses indoor units which can heat or cool the zones by the expansion and compression of a refrigerant
- Temperature control is achieved by varying the mass flow of the refrigerant
- The DOAS supplies the interior space with the necessary amount of outdoor air
- It can have a coil in order to pre-cool the outdoor air and supply it at a lower temperature inside the space



* Picture is taken from TRANE's website

Monitoring clean energy in the EULiST campuses

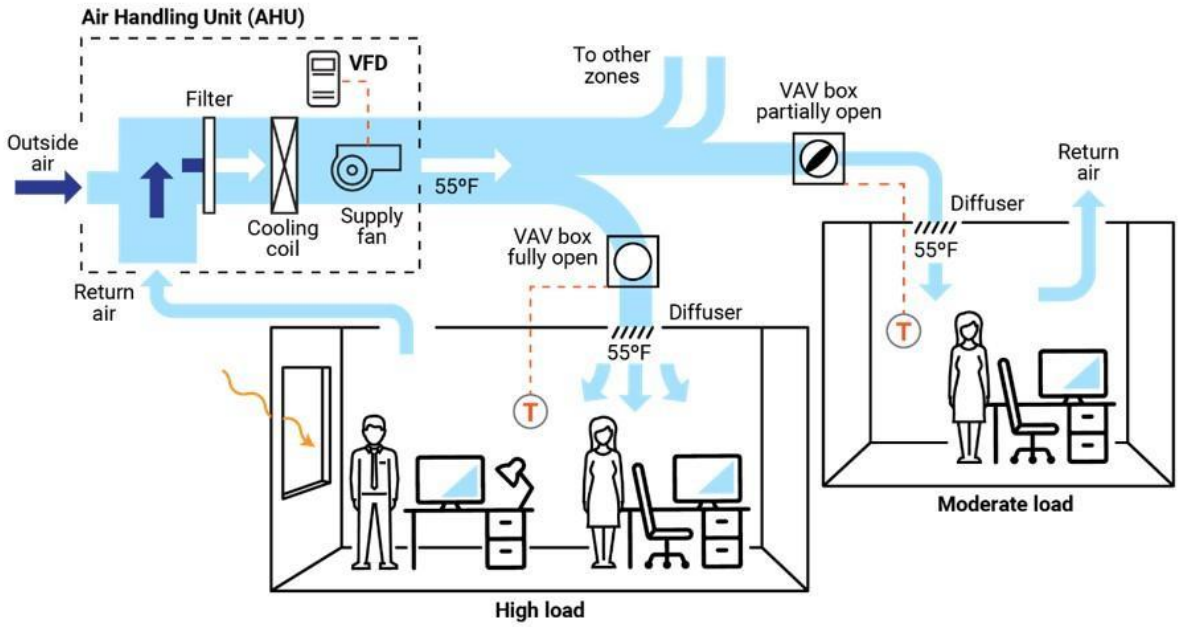
Project title: Eco-Friendly Sustainable Campus

Simulation Scenarios

STEP 3: Simulation Scenarios

Variable Air Volume System (VAV)

- The VAV is one of the most energy – efficient system for HVAC
- VAV allows for both recirculation of inside air and supply of outdoor air inside the selected zone
- The temperature control is achieved by varying the mass flow of water in its coils as well as the mass flow of supplied air in the zone



* Picture is taken from https://www.pnnl.gov/

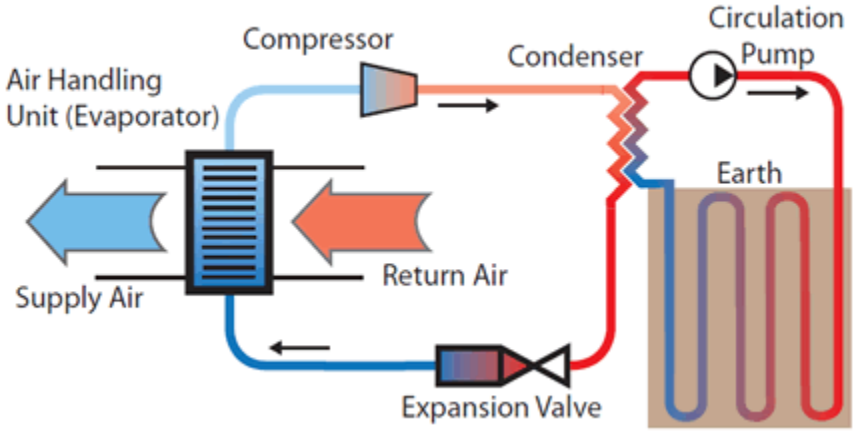
Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus - STEP 3: Simulation Scenarios

Simulation Scenarios

Ground Source Heat Pump (GSHP) + Dedicated Outdoor Air System (DOAS)

- Ground Source Heat Pumps take advantage of ground's stable temperature and as a result it is more energy efficient
- The coils of the HVAC system are usually connected to the GSHP
- In order to cool the space an amount of heat is transferred from the room into the ground and in reverse in order to heat the space
- The DOAS supplies the interior space with the necessary amount of outdoor air



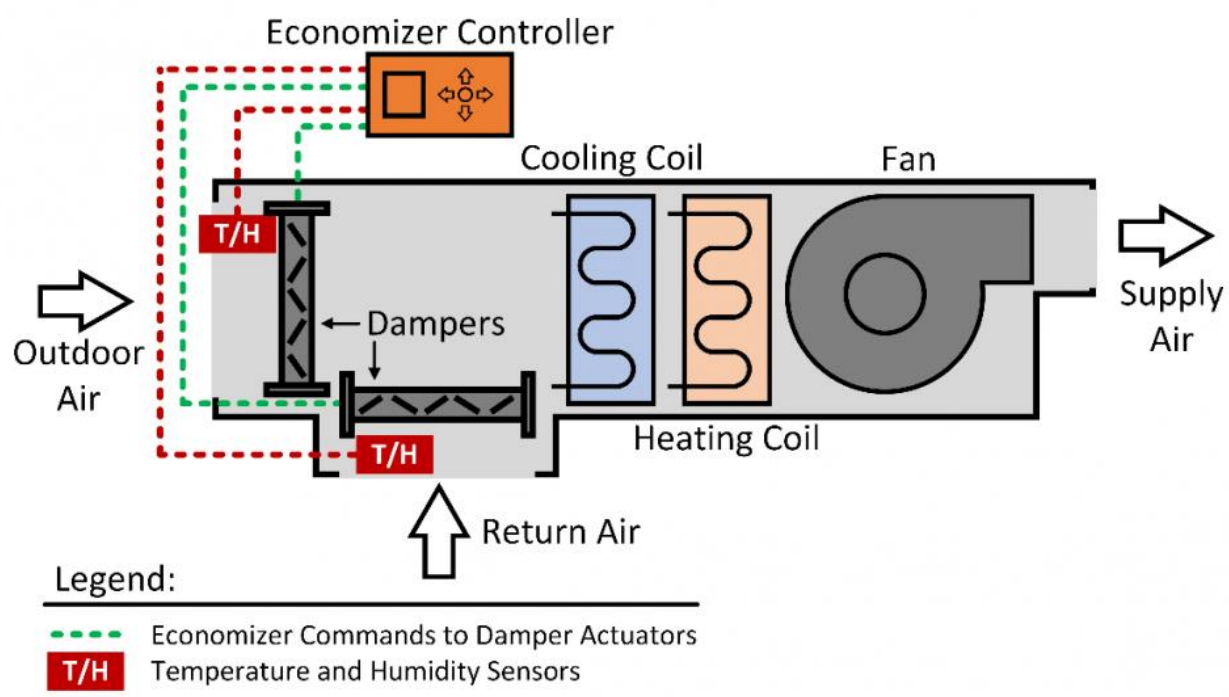
Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus - STEP 3: Simulation Scenarios

Simulation Scenarios

Economizer

- Economizer is a control system that allows outdoor air to be supplied to the space, without any treatment
- There are different types of economizers depending on the control variable
- The most common one is the Dry-Bulb control Economizer



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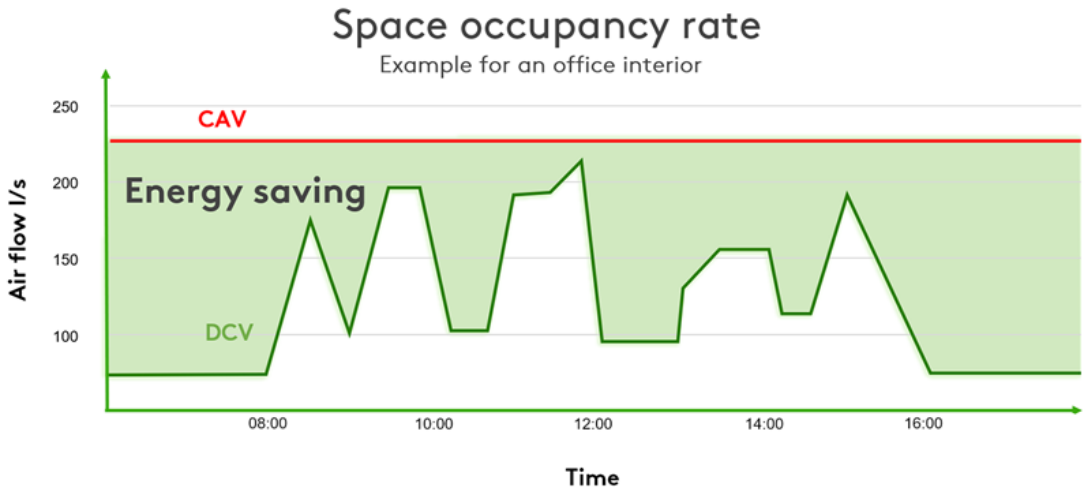
Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus - STEP 3: Simulation Scenarios

Simulation Scenarios

Demand Control Ventilation (DCV)

- Demand controlled ventilation (DCV) is a feedback control method
- It maintains indoor air quality by adjusting the ventilation rate provided to a space in response to changes in conditions such as occupant number or indoor pollutant concentration.
- The ventilation rate can be changed either for a single space or a group of them



* Picture is taken from https://www.swegon.com/

Monitoring clean energy in the EULiST campuses

Project title: Eco-Friendly Sustainable Campus - STEP 4: Documentation and Analysis

STEP 4: Documentation and Analysis:

- a. Document the key findings and observations from the simulation results.
- b. Analyze the energy consumption patterns and identify areas for further improvement.
- c. Summarize the effectiveness of the energy-saving strategies implemented and their impact on the PB's energy performance.
- d. Investigate the cost optimal scenario (cost vs energy savings and return of investment)

Thank you for your attention!

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URL: http://thermolab.mech.ntua.gr/v2/