Advanced Technologies for Energy Efficient Mediterranean Building

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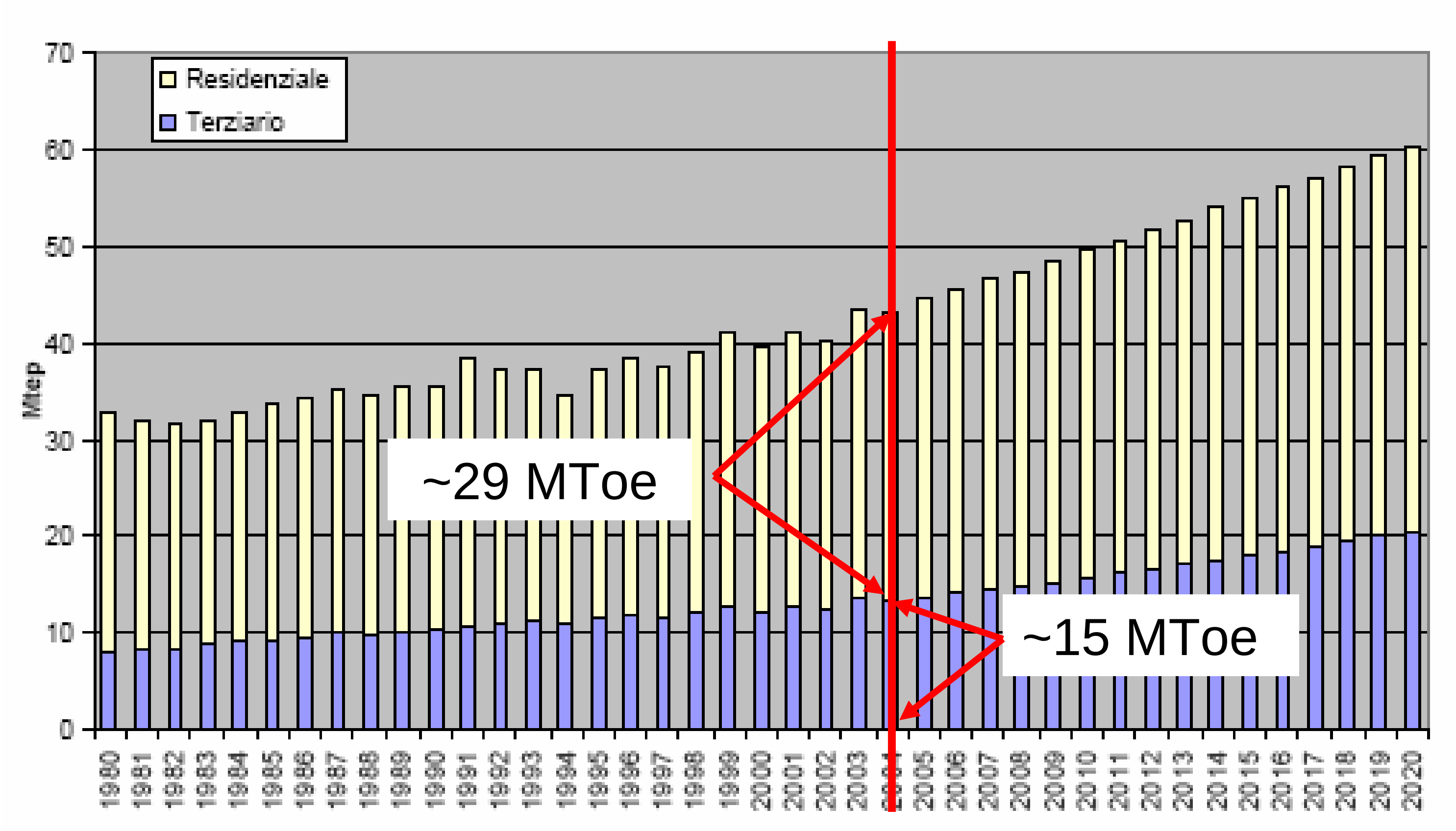
Driving Forces for improving Building EE in Mediterranean Countries

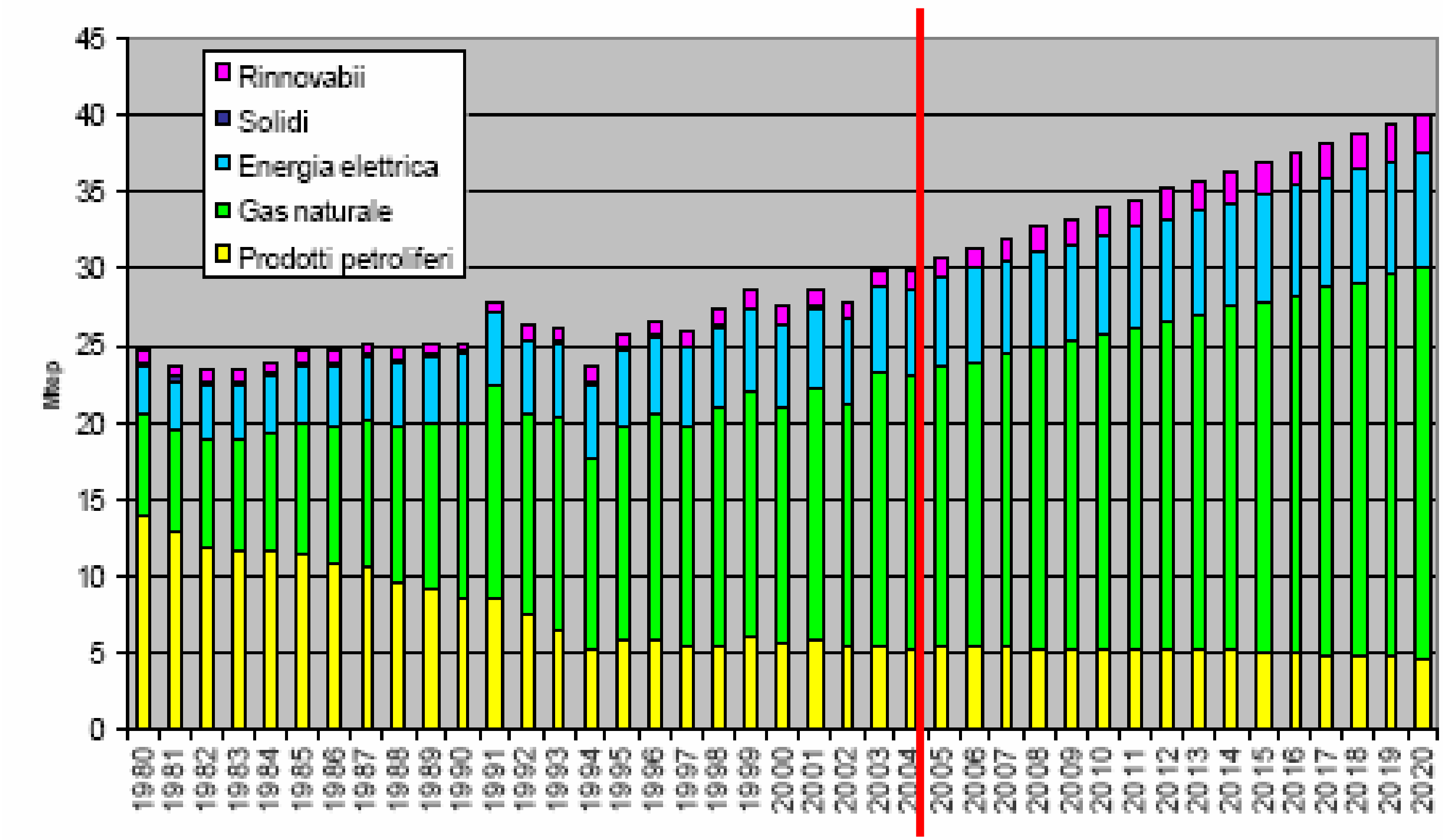
- Climate changing – global warming
  - Cooling season will be longer
  - Cooling loads will be higher
  - Energy bill will increase especially for air conditioned buildings
- Scarcity
  - Increased lack of natural resources
  - Need for more effective use of energy and materials
  - Pressure for increase in price
- Legislation
  - Kyoto's Protocol
  - EBPD (..in UE countries..)
  - Emissions (CO_2, NOx, SOx...)

Energy consumption in building sector in Italy

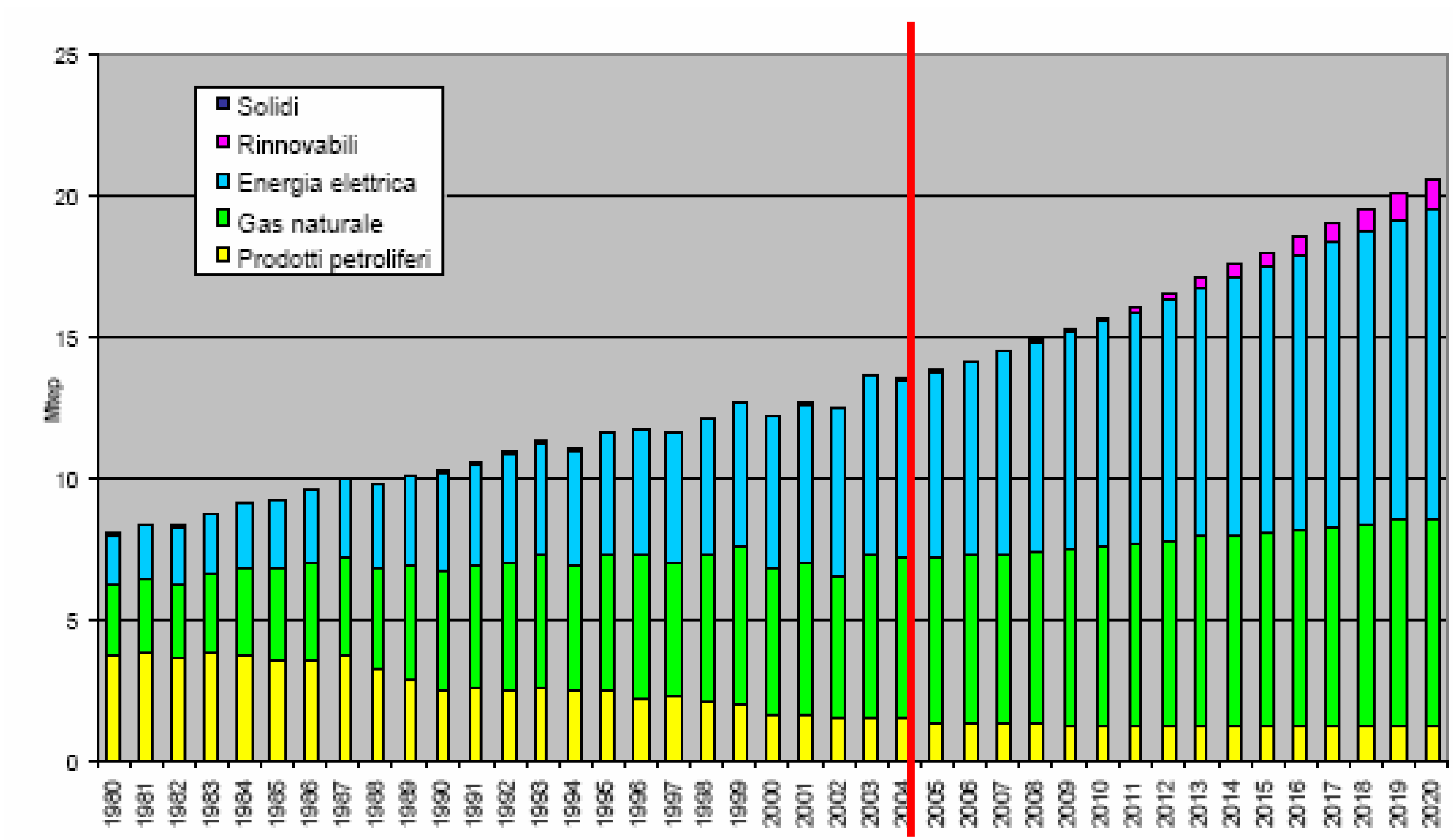


Primary energy: source Ministery of Economic Development

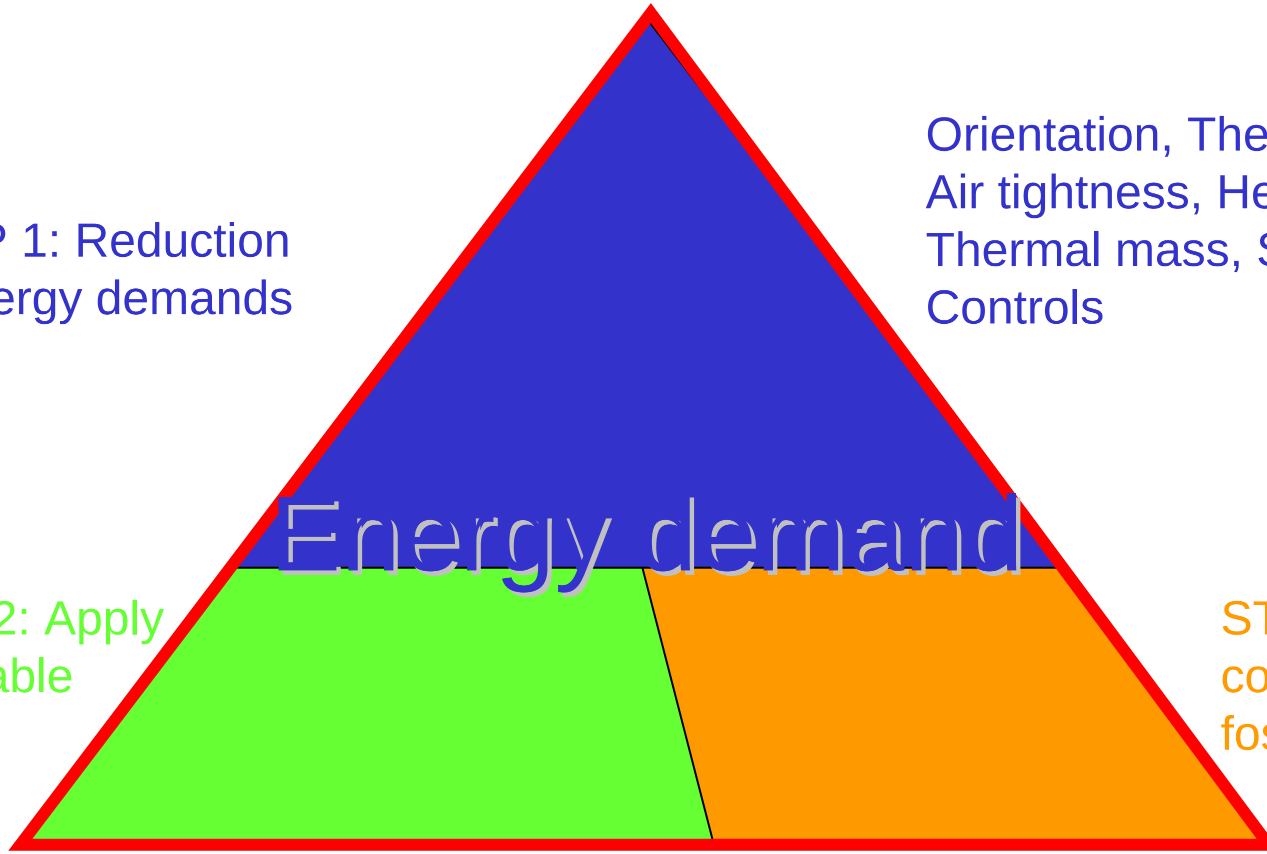
Residential buildings: share per energy source



Tertiary Buildings: share per energy source



Eco-building approach



STEP 1: Reduction of energy demands

Orientation, Thermal Insulation, Air tightness, Heat recovery, Thermal mass, Solar shading, Controls

STEP 2: Apply renewable energy

STEP 3:Efficient conversion fossil techniques

Sun, heat pump, wind, biomass

TG, CHP, HE-boiler, HE- lighting

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There is not "the" solution.. but

- A mix of possible solutions, based on integration of
  - Building design concept
  - Building envelope technologies
  - Renewable integration
  - Sustainable HVAC systems
  - Polygeneration strategies

Energy efficient building: from component to concept

- **Building**

- Thermal insulation
  - Rc-facade, roof, floor
  - Uwindow, Uglass
- Air tightness
  - qv;10, n50
- Orientation
- Sun optimal
- Solar shading
- Thermal mass

Ventilation

- Natural
- Mechanical
- Demand controlled
- Heat recovery
- Night ventilation
- Openable windows

Installations H, C, DHW, CHP

Gas fired boiler

- Chillers
- Heat pump
- High temperature systems
  - Radiators, convectors
- Low exergy systems
  - Radiant systems
- District heating/cooling
- Trigeneration
- Solar collector
- Controls and metering
- Buffering
- Distribution

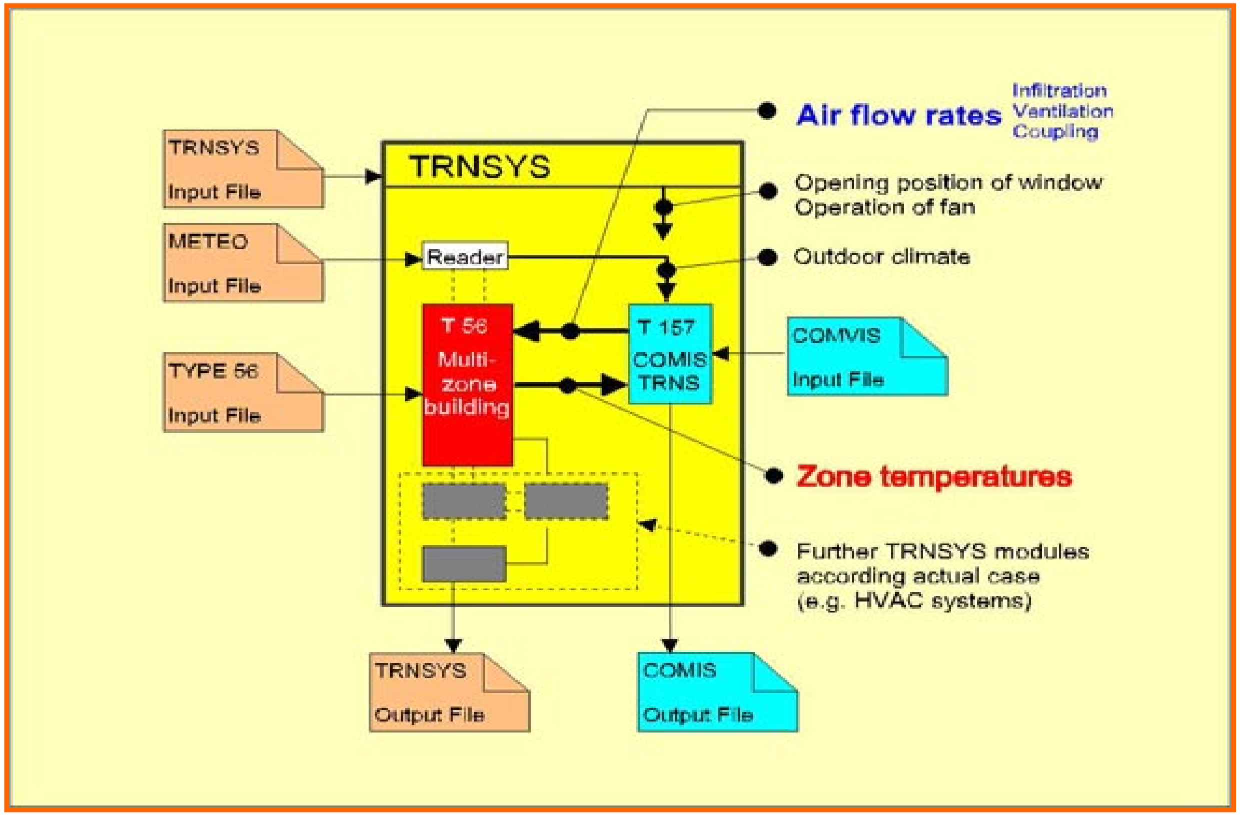
Design process

- Design process of an Eco building is much more complex than design process of usual buildings, where different systems are less interconnected.
- Many variables are, contemporarily, on the table.
- Many knowledge have to be exchanged between different actors.
- Designers have then to take into account interactions between
  - building and climate
  - building and plants
  - plants and users
  - users and building

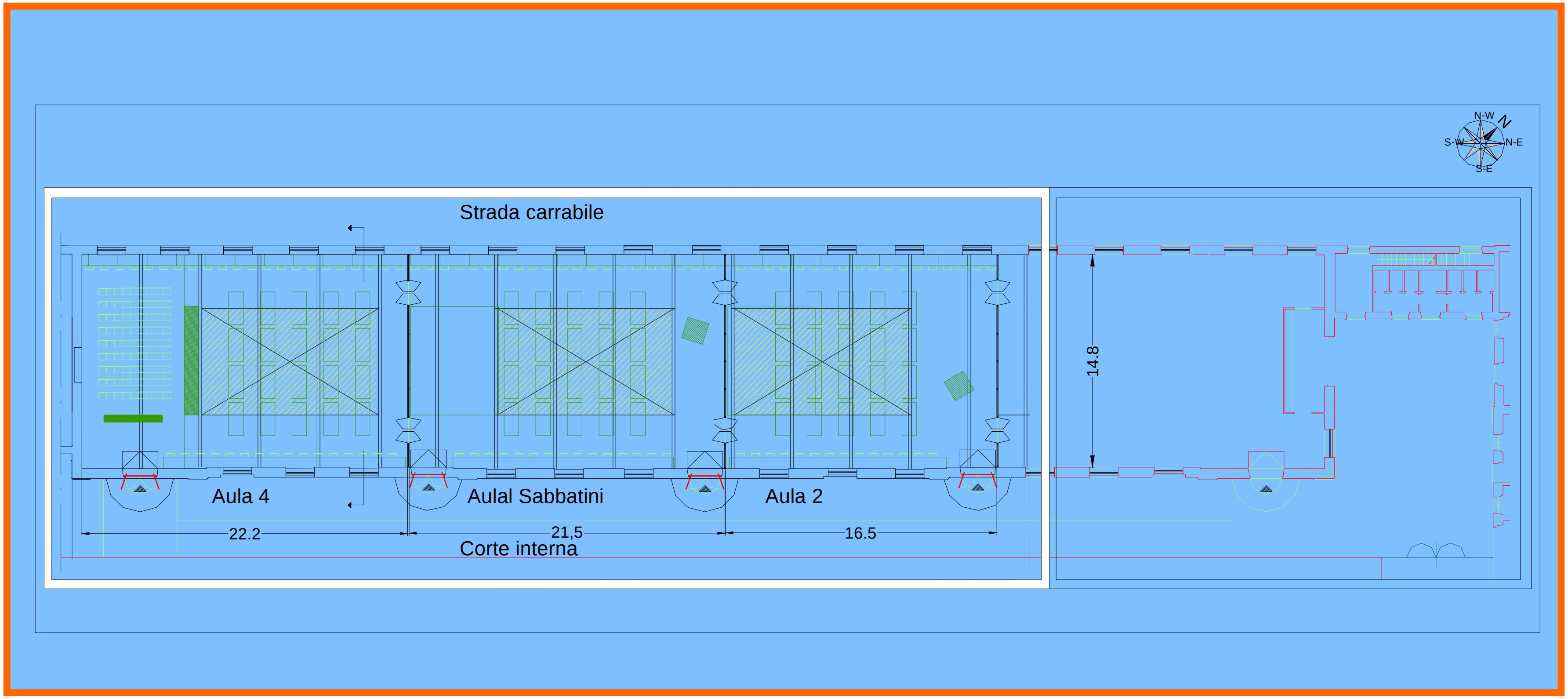
Integral approach...

- Integral approach is then a prerequisite of ecobuildings design. Lack of design tools is crucial and still an open issue.
- This lack is usually overtaken with closer cooperation between architects and engineers.
- Design process becomes iterative.
- What was considered solved in a previous round can change during the following round, or, even more frequently, the solution of a problem opens another problem.

Eco-building design tools: Dynamic Simulation Models



Case study



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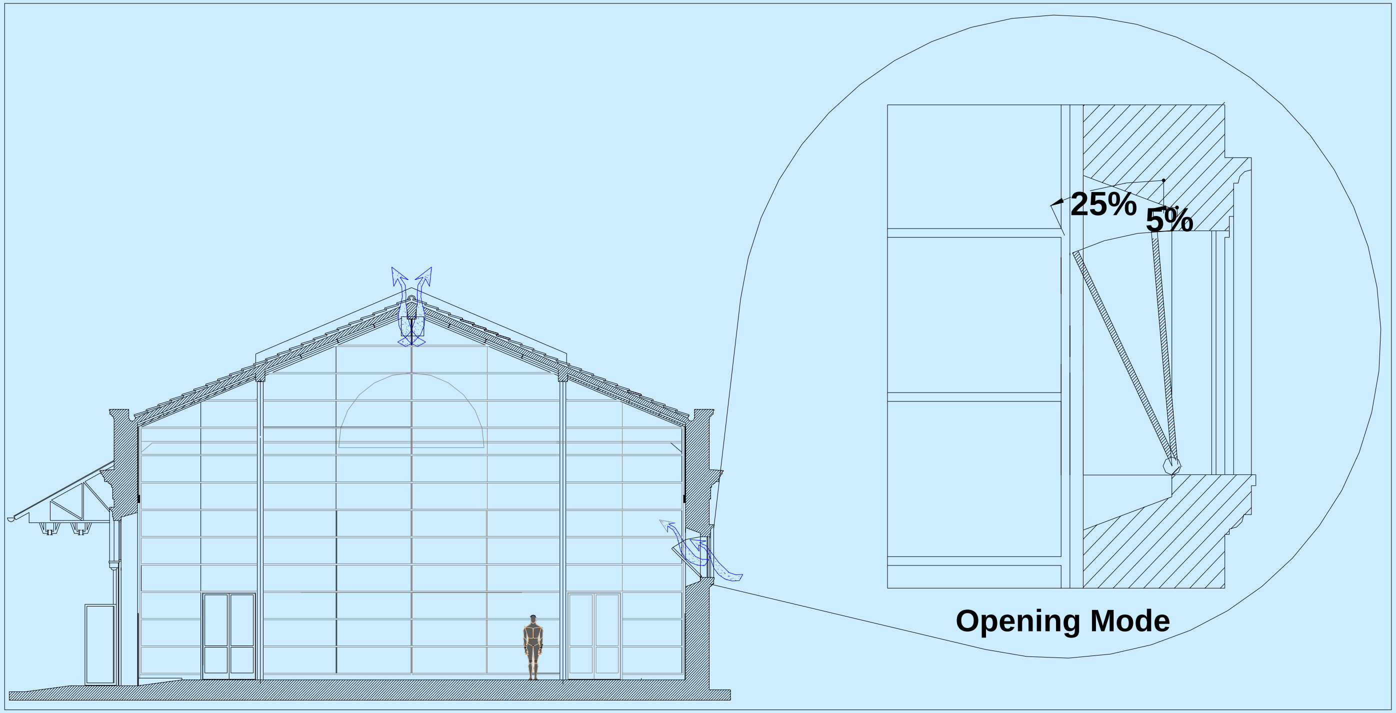
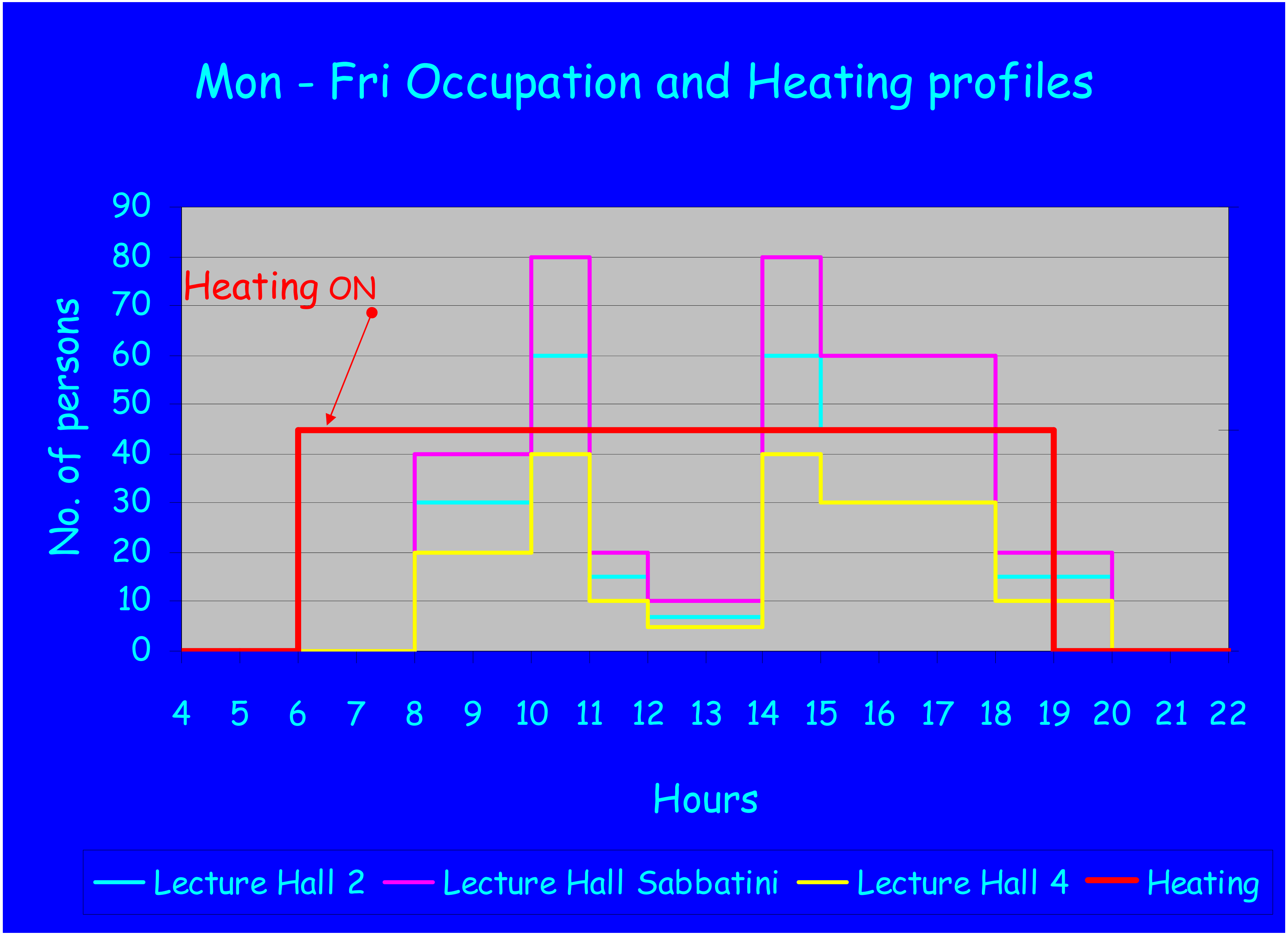
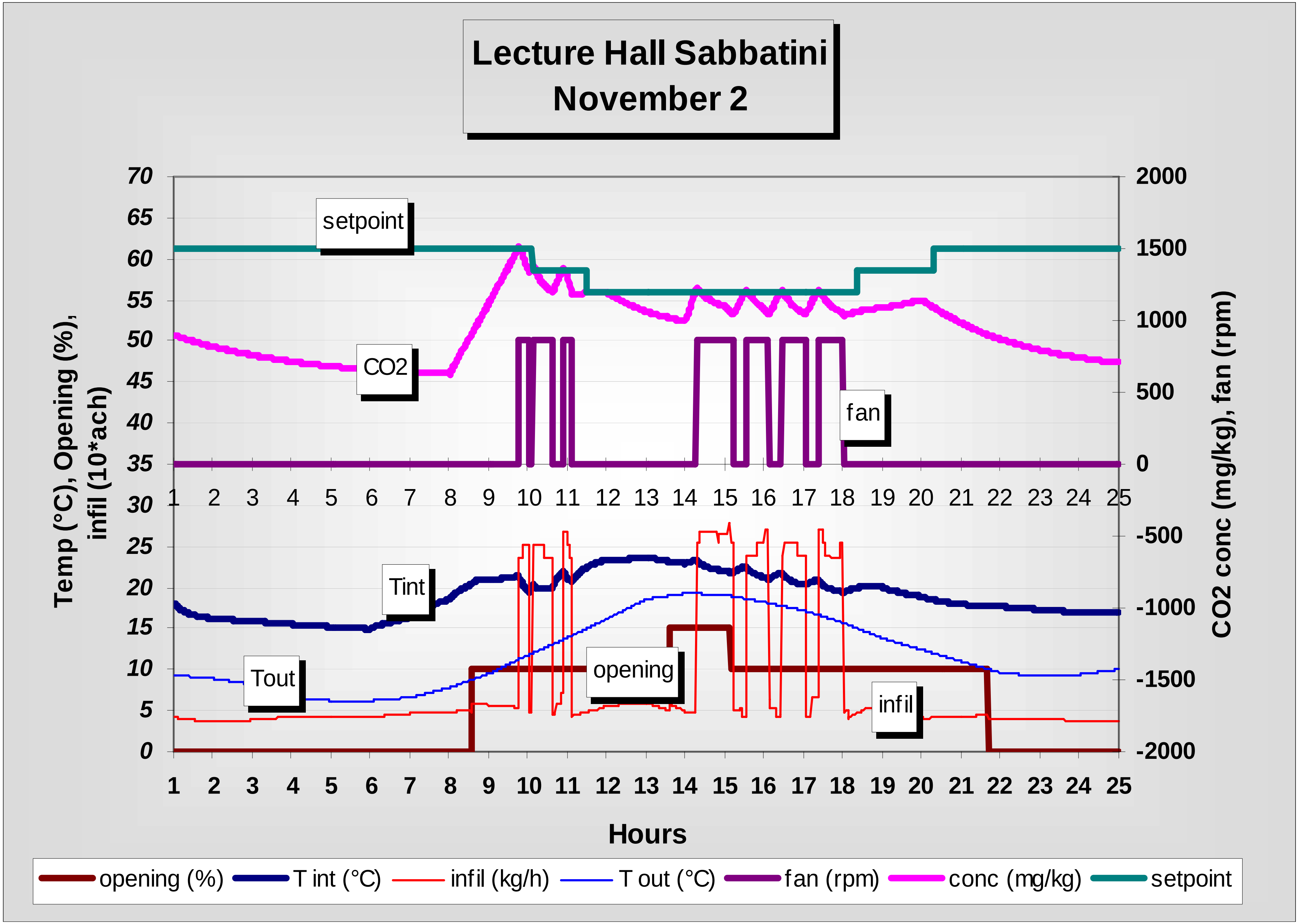
Case study description

Ventilation strategy

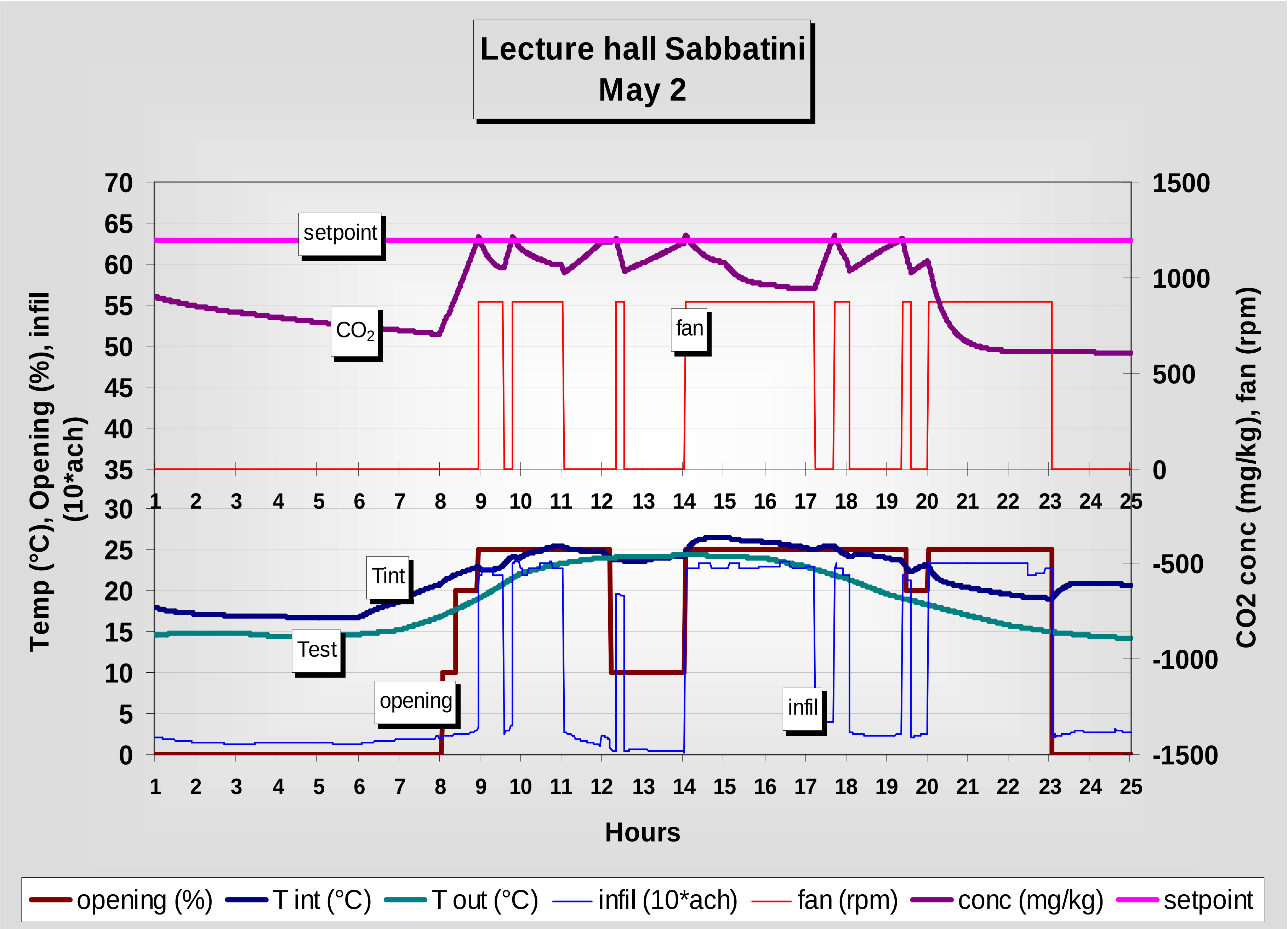




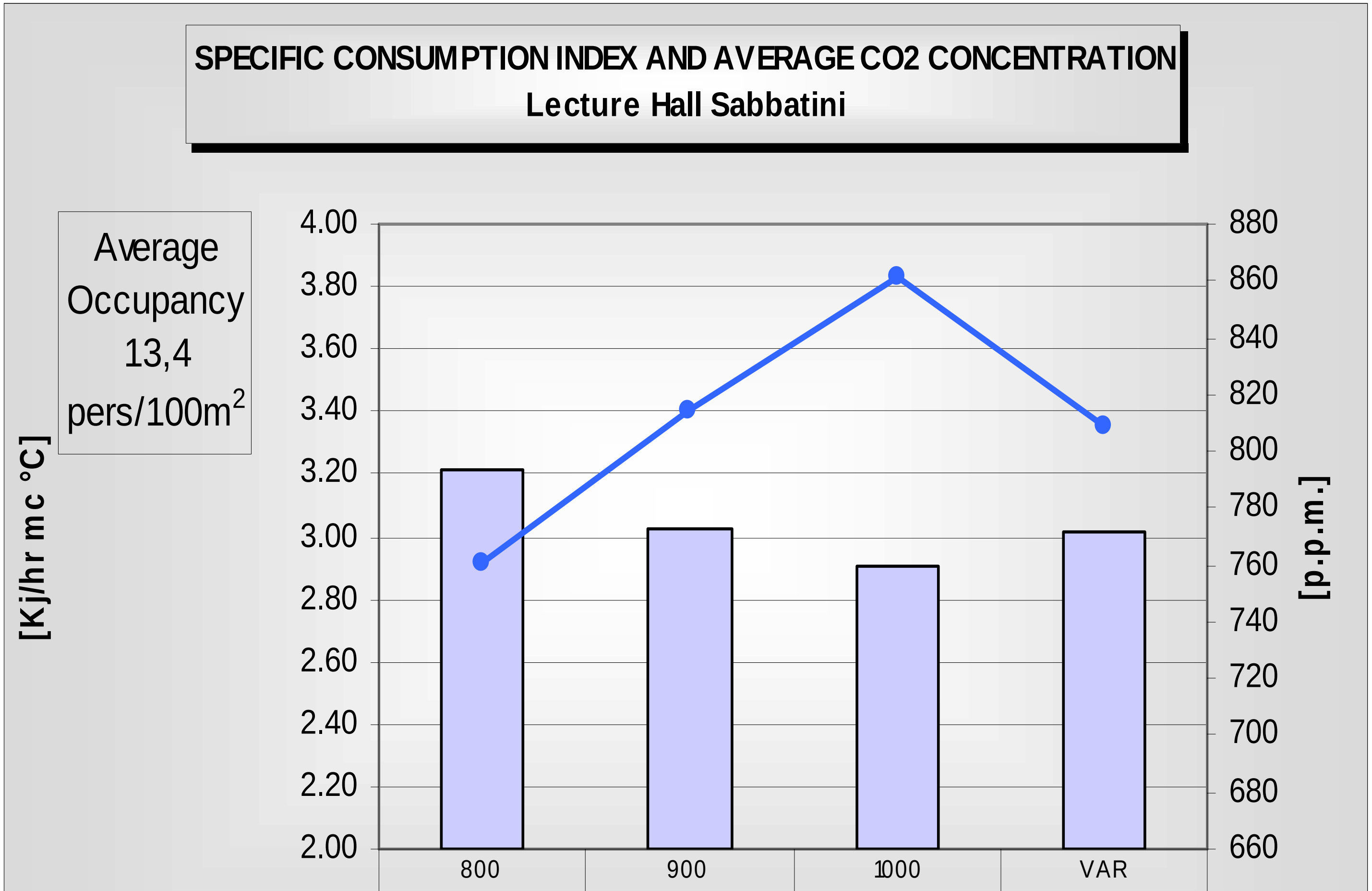
Mon - Fri Occupation and Heating profiles
Heating ON
No. of persons
90
80
70
60
50
40
30
20
10
0
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Hours
Lecture Hall 2
Lecture Hall Sabbatini
Lecture Hall 4
Heating



Lecture Hall Sabbatini
November 2
setpoint
CO2
fan
Tint
Tout
opening
infil
Temp (°C), Opening (%), infil (10*ach)
CO2 conc (mg/kg), fan (rpm)
Hours
opening (%)
T int (°C)
infil (kg/h)
T out (°C)
fan (rpm)
conc (mg/kg)
setpoint



Lecture hall Sabbatini
May 2
setpoint
CO2
fan
Tint
Test
opening
infil
Temp (°C), Opening (%), infil (10*ach)
CO2 conc (mg/kg), fan (rpm)
Hours
opening (%)
T int (°C)
T out (°C)
infil (10*ach)
fan (rpm)
conc (mg/kg)
setpoint

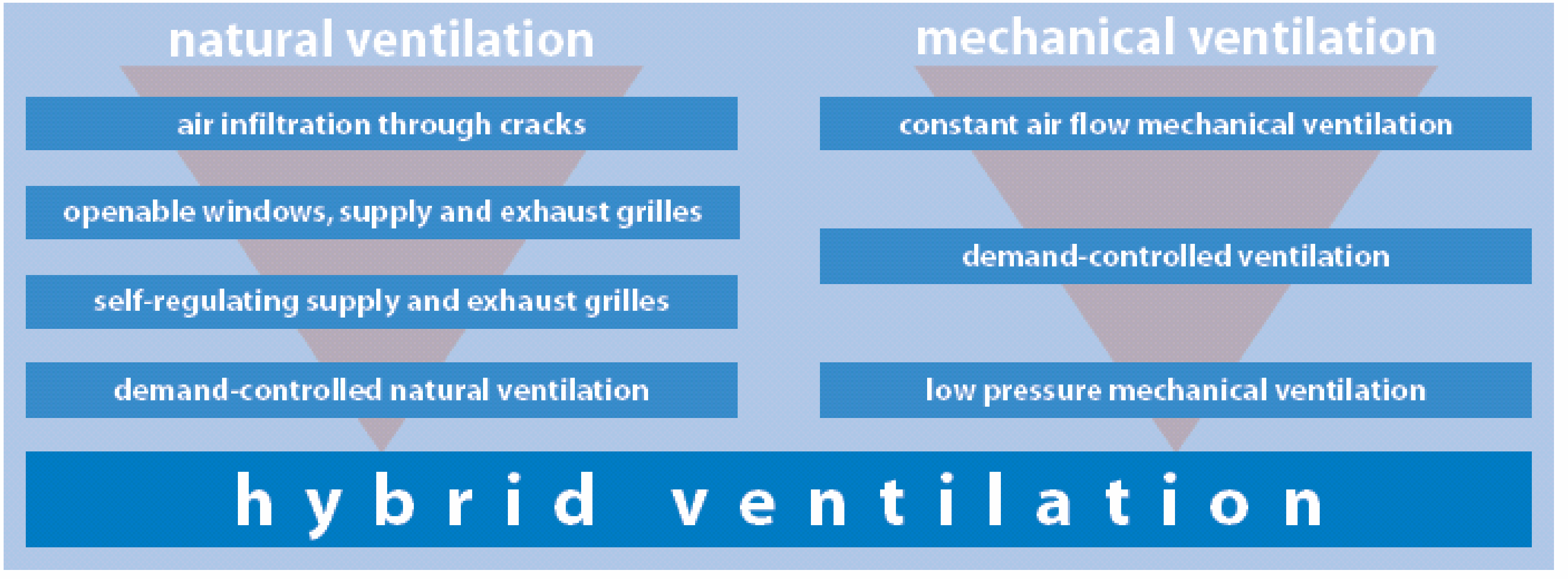


	800	900	1000	VAR
Specific Consumption Index	3.21	3.02	2.90	3.02
Average CO2 Concentration	761	815	862	809

Most suitable strategies for Mediterranean Countries

- Hybrid ventilation
- Passive cooling
  - Ground cooling
  - Night cooling
- Ground storage
- Polygeneration

From natural to hybrid ventilation



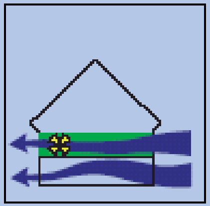
Hybrid ventilation typologies

Ventilation Principles

The main hybrid ventilation principles are:

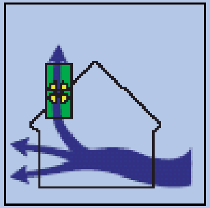
Natural and mechanical ventilation

This principle is based on two fully autonomous systems where the control strategy either switches between the two systems, or uses one system for some tasks and the other system for other tasks. It covers, for example, systems with natural ventilation in intermediate seasons and mechanical ventilation during midsummer and/or midwinter; or systems with mechanical ventilation during occupied hours and natural ventilation for night cooling.



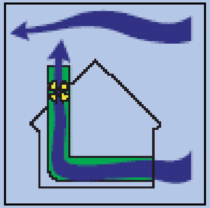
Fan-assisted natural ventilation

This principle is based on a natural ventilation system combined with an extract or supply fan. It covers natural ventilation systems that, during periods of weak natural driving forces or periods of increased demands, can enhance pressure differences by mechanical (low-pressure) fan assistance.



Stack- and wind-assisted mechanical ventilation

This principle is based on a mechanical ventilation system that makes optimal use of natural driving forces. It covers mechanical ventilation systems with very small pressure losses, where natural driving forces can account for a considerable part of the necessary pressure.



Ground cooling

- Ground temperature is almost constant all over the year at few meters depth.
- Ground temperature can be considerably lower than ambient temperature in summer.
- This phenomena can easily exploited for cooling supply air during summer.

Ground Cooling

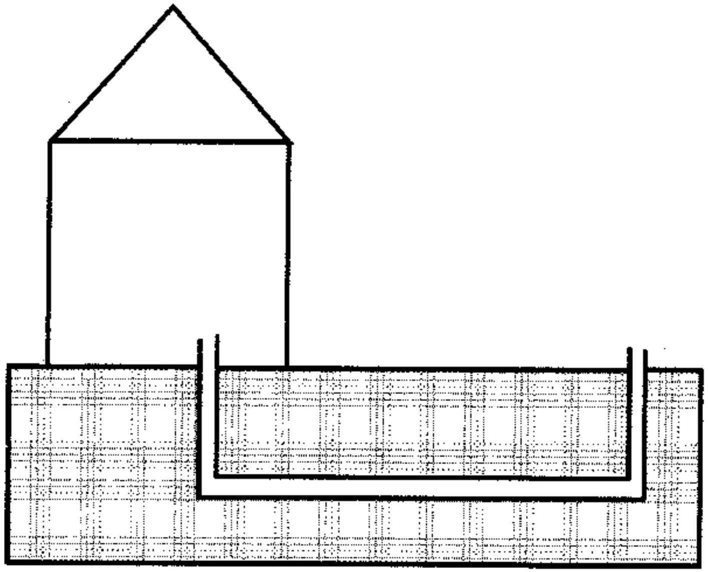
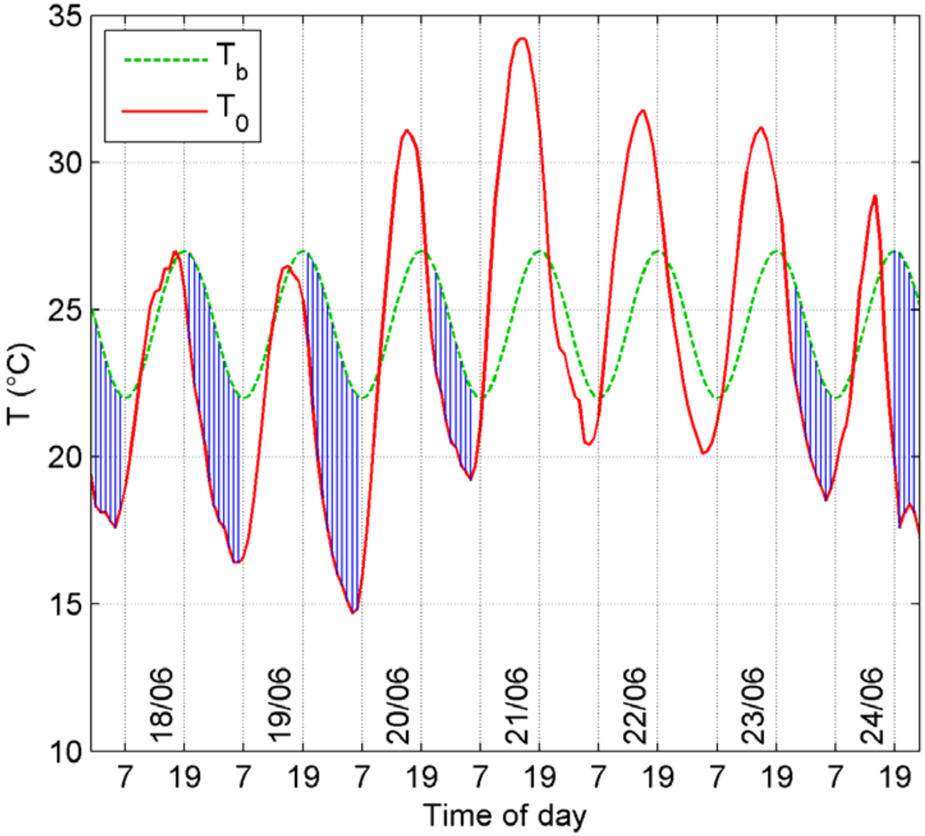


Figure 11.7 Principle of earth-to-air heat exchangers, linked to a building

Air temperature drop depends on:

- Inlet temperature,
- Ground temperature at duct level,
- Thermal Conductivity of the duct
- Ground thermal diffusivity, $a = \lambda / \rho c$
- Air velocity and duct dimensions.

Night cooling



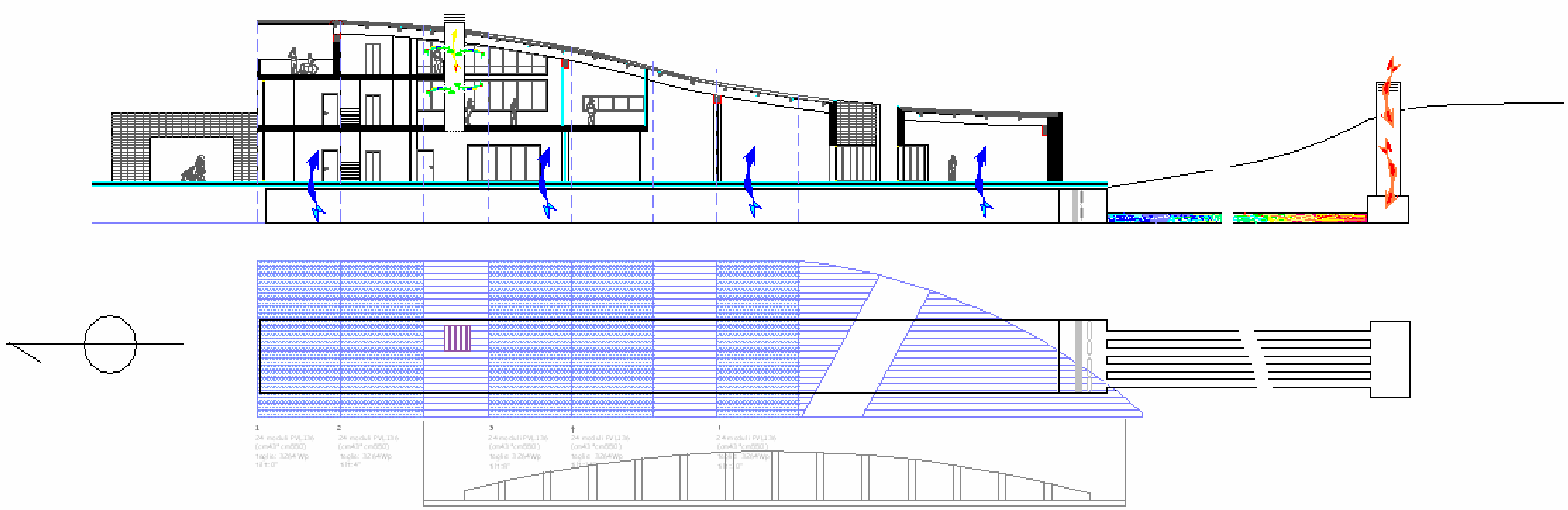
Night cooling: requisites

- Climate has to be characterized by considerable daily thermal excursions.
- Night cooling should be preferable adopted in buildings with heavy thermal mass
- Night cooling is more efficient if:
  - Supply air velocity is high
  - Supply grilles or opening are close to heavy structures (floor or ceilings)

Night cooling

- Night cooling benefits:
  - Reducing functioning time of cooling plants.
  - Moving switch-on time of cooling plants later in the morning.

Ground Cooling an example in south Italy



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Ground and Night Cooling: Saving potential

- South italian climate
- 2400 mc building
- 4 pipes 50 m length
- 2 ach
- Proper control strategy

Up to 30 % reduction in cooling demand

Ground storage

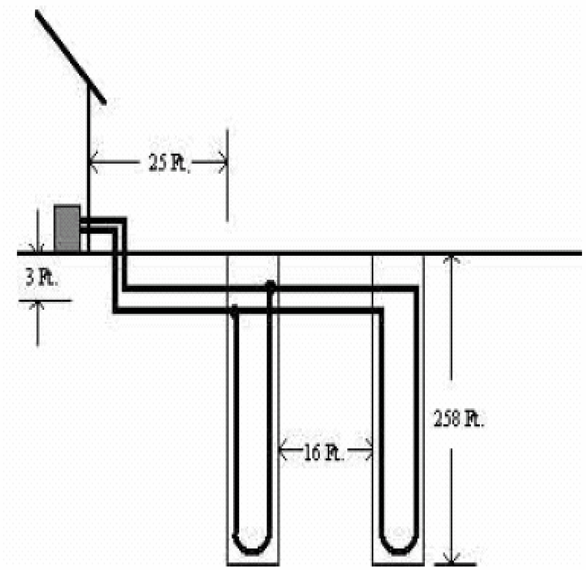

Figure 1: Ground Heat Exchanger Configuration

Geothermal heat pumps can exploit ground as seasonal storage

Ground storage

- Geothermal Heat Pumps use the natural heat storage capacity of the earth or ground water to provide energy efficient heating and cooling
- This system stores the cooling energy in winter, which can then be used during summer by GHP as cold source: its efficiency increses substantially.

The importance of Control Strategies

- An efficient control system of building environment and HVAC plant is often necessary condition for achieving energy efficiency of a building.
- The development of an "optimal" control strategy for a specific building will depend not only by technical parameters as building type and design, ventilation and climatization plants, and so on, but also on parameters such as dress code, user attitude and user expectations.

The importance of Control Strategies

- In general in each building there is a strong interaction between the energy plant and the control system.
- In buildings with active components, this aspect is enlarged to the envelope also; it is therefore important that all these parts are designed together in one process and a strong co-operation between architects, HVAC engineers and control engineers is necessary.

Control Strategies techniques overview

Traditional “fixed rules based”

Fuzzy logic

Optimum and predictive, simulation assisted

Neural networks

Adaptive, artificial life based, techniques

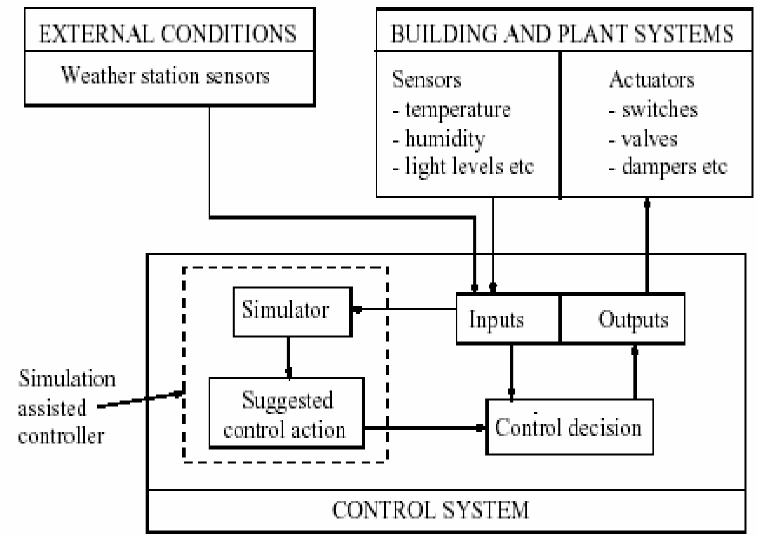

Figure 1: Simulation assisted control in BEMS.

Efficiency in Energy supply

Trigeneration and Polygeneration

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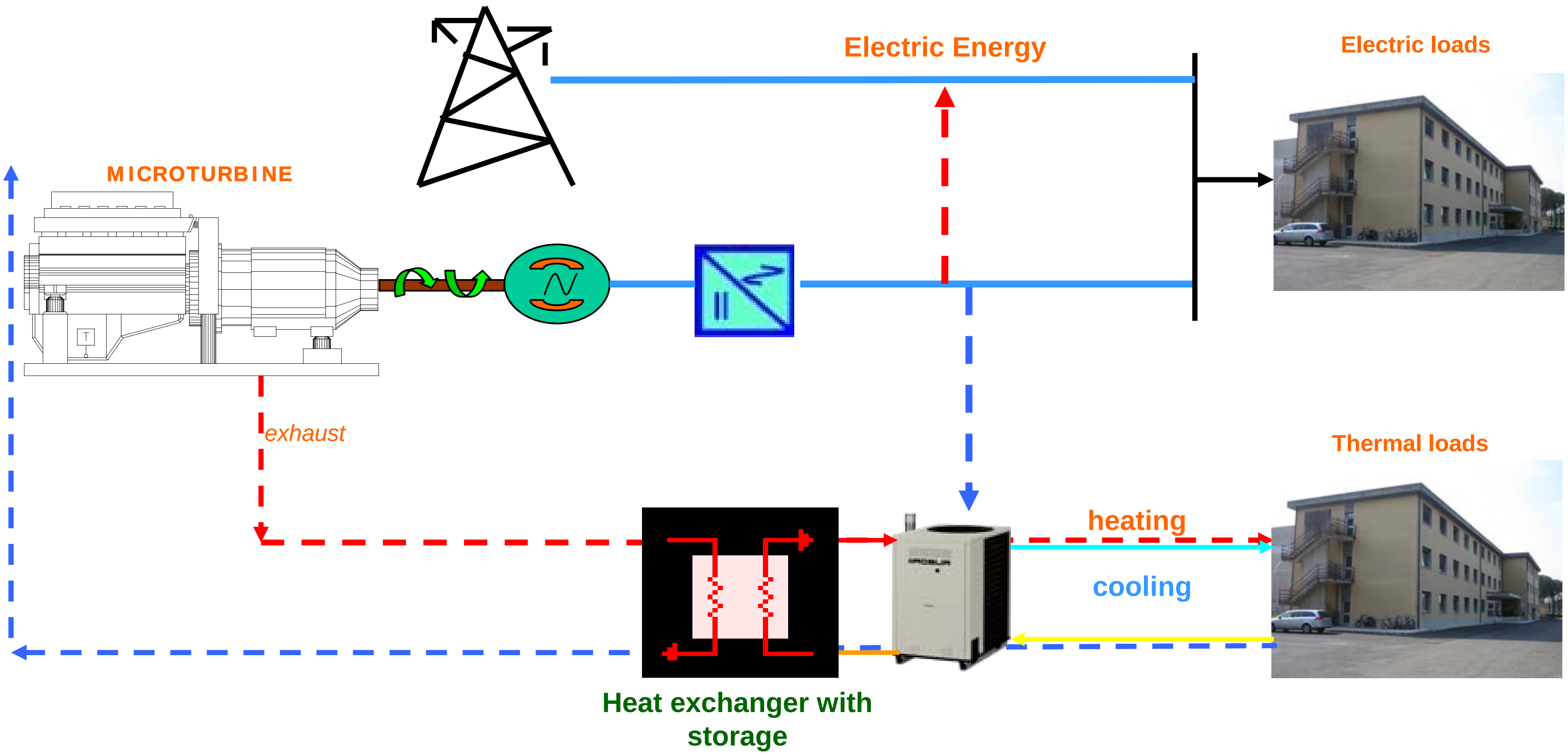
Trigeneration



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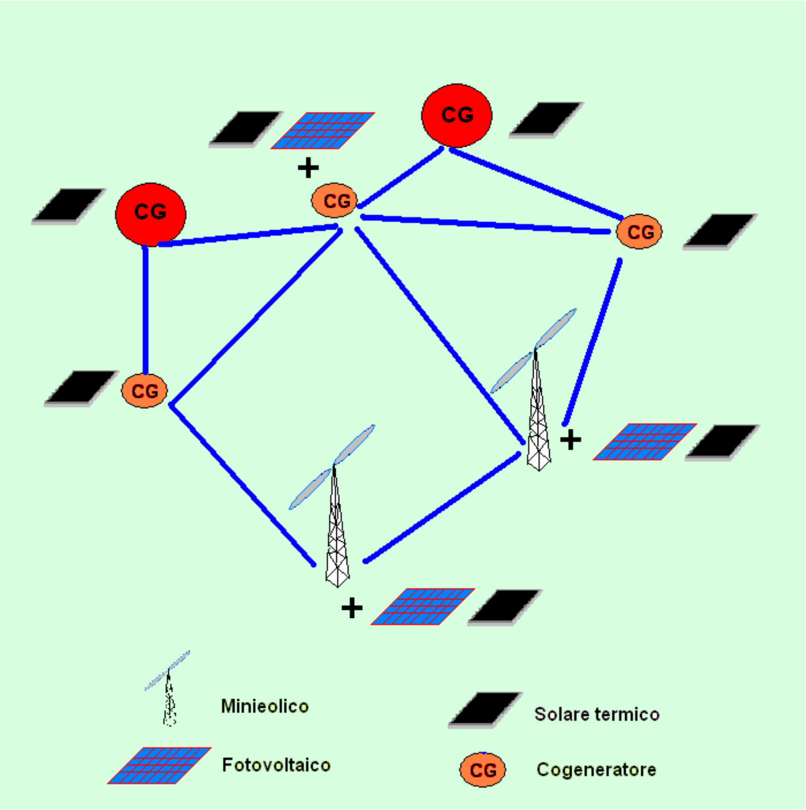
Polygeneration

- Integration between Trigeneration and Renewables technologies
- Polygeneration can achieve substantial benefits in a framework of Distribute generation
- Users exchange energy with other users

Polygeneration and Distribute Generation



Conclusions

- Achieving a substantial improvement of building energy efficiency in Mediterranean countries is becoming a must
- New and “old” technologies are available

Conclusions

BUT…

They need the development of new concepts and design tools

Thanks for your attention