Project: Design & development of a laboratory building of CRES, with implementation of RES technologies, in Pikermi, Attiki

Building Volume		
Total area	1464	m^3
Basement area	483	m^3
Ground floor area	519	m^3
1^{st} floor area	462	m^3
Building Area		
Total area	529	m^2
Basement area	173	m^2
Ground floor area	189	m^2
1^{st} floor area	167	m^2
Roof	171	m^2
Net Headed Building Area		
Total area	428	m^2
Basement area	127	m^2
Ground floor area	154	m^2
1^{st} floor area	147	m^2
Windows Surface		
Total area	53	m^2
North	8	m^2
South	17	m^2
East	14	m^2
West	14	m^2
Greenhouse Windows Surface		
Total	15	m^2
South	12	m^2
West	3	m^2
Clerestories Windows		
Total area	14	m^2
North	7	m^2
South	7	m^2
Greenhouse Area		
Total area	8,25	m^2
Solar Wall Surface (thermosyphonic)		
Total area	17	m^2
Right	8	m^2
Left	9	m^2
Transparenti insulation Surface	8	m^2
Thermal characteristics		
Roof from Reinforced concrete slabs	0,33	W/m^2K
Reinforced concrete vertical structural elements	0,65	W/m^2K
Brickwork vertical structural elements	0,52	W/m^2K
Brickwork vertical structural elements with transparent insulation	0,53	W/m^2K
Reinforced concrete floor in non-heated areas	0,58	W/m^2K
Openings	3,72	W/m^2K
Thermal conductance coefficient of the Transparent Insulation[λ]	0,044	W/mK
Thermal conductance coefficient of Tektalan [λ]	0,04	W/mK
Overall heat transfer coefficient [k_m]	0,82	W/m^2K
Overall external surface / Volume [F/V]	0,66	m^{-1}
Photovoltaic panels, 600 Wp	8,64	m^2
Users	20	Persons
Site and Climate		
Longitude	23°.55´	E
Latitude	38°.01´	N
Altitude	153	m
Average ambient temperature (annual)	18,7	°C
January	9,4	°C
July	28,7	°C
Degree Days (base 19 °C)	1218	days
Global irradiation on horizontal (annual)	1747	KWh/m^2
Costs (1999 prices)		
Conventional construction	352.000	EURO
Energy systems	39.780	EURO

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Bioclimatic and Low Energy Office Building

ΚΑΠΕ
CRES
CENTER FOR RENEWABLE ENERGY SOURCES
19th km MARATHONOS AVE. PIKERMI GREECE

Detail of external brickwork with external insulation

For the insulation of vertical building elements, 5 cm Tektalan panels were used(glass fibre with panels of dried seaweed).

At chosen sites on the south face, 5 cm Sto Therm Solar transparent insulation panels were used and the roof was insulated with 5cm extruded polystyrene Dow Roofmate panels.

The floors were laid with 30x30 cm ceramic tiles.

The windows are Europa aluminum, white, double paned 22 mm thick, with a space between them of 12 mm and two glass panes, each 5 mm thick.

Passive and Hybrid Solar Sytems

The building design specified the incorporation of passive solar systems (P.S.S.), the aim of which is to use solar energy for heating:

- ✔ Direct gain systems (openings on the south face with a total area of 17 m2) for collecting solar radiation for passive heating during the winter.
- ✔ Greenhouse with an area of 8.25 m2 added to the south face of the building, with openings of 12 m2 where solar radiation is collected as heat and is distributed through openings in the building.
- ✔ Solar air collectors air panels with a total area of 17 m2 incorporated into the south face of the building which collect solar radiation and give off heat either through openings (direct) or as preheated air to a heat pump on the roof (indirect).
- ✔ Solar atrium (glazed part of the roof of the building with an area of 14 m2) to collect solar radiation and produce thermal energy to heat the central internal part of the building.
- ✔ Transparent insulation with a total area of 8 m2 to reinforce solar gains on the south facing parts of the building..

Daylighting

Parallel to and in conjunction with the passive solar systems, daylighting systems were studied in order to provide the building with natural light for the greatest possible part of the day resulting in a reduction of electricity required for lighting. For this purpose, the following were designed:

- Roof lighting system partially glazed roof to let in natural light for the central part of the building.
- Atrium onto which internal doors open to allow daylighting to enter the innermost parts of the building.

The solar atrium is used as a passive cooling system, for direct natural lighting and solar radiation

Passive Cooling Techniques

To avoid overheating and reduce air conditioning requirements were the goals of the passive cooling systems. The following were installed or applied:

- Shading systems (vertical awnings) on the south facade, vertical window blinds on the east west facades) combined with internal venetian blinds.

Sun protection systems on the south and east facades

- Natural cross ventilation techniques with window openings, fans or skylights.
- Natural ventilation systems through mechanically operated openings in the roof and backed up with fans.

Use of Renewable Energy Sources in the HVAC System

❖ *Geothermal water to water heat pump*

During the winter period, water from the well comes through the evaporator of the geothermal water to water heat pump and provides heat to the chilling cycle (the design temperatures for the circulation of the stored water are 18/2 C). At the same time, the heat pump condenser heats the separate circulation of the water in the fan coil network on the ground floor and provides heat for it, thus raising the temperature which was reduced by the heat loss load of the building(the temperatures specified for the fan coil units is 45/40 C). The system works the same way during the summer period. The unit uses the stored water of the existing well which is 80 m deep, located 10 m north of the building. The temperature of the well water was measured in May at 21 C and the well provides water at a rate of 1.2m3/h. The heat pump has a refrigeration power of 16 Kw and a heating power of 17.5 Kw. It is R22

Geothermal water to water heat pump

Solar assisted water - air heat pump

technology with a reciprocating compressor and set step at 0-100. The COP factor of the heat pump for the above temperatures is 4.2 and the water heat exchanger is a concentric type.

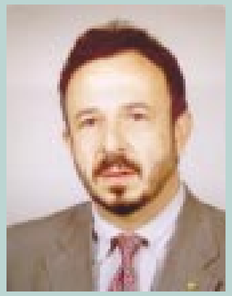
❖ *Solar assisted water-air heat pump*

The cooling and heating load of the first floor is covered by a solar assisted 18 Kw air-water heat pump.

During the winter, the air, pre-warmed by the solar air collectors with a total area of 17 m2 and with a specified supply rate of 1700 m3/h, is drawn into the evaporator of the solar assisted air-water heat pump, aided by centrifugal fans and supplies heat to the refrigeration cycle (the temperatures specified for the circulation of the prewarmed fresh air is 10/3 C)

The distribution network of the first floor heat pump is similar to that of the ground floor heat pump.

The heat pump has a chilling power of 16.5 Kw and heating at 18 Kw.



A significant amount of energy consumed in buildings can be saved with a simultaneous improvement in conditions for their occupants through:

- Bioclimatic design
- Construction with suitable insulation
- The application of energy conservation technologies and renewable energy sources
- The rational energy management of building functions

We have applied all of these to the new office building at CRES and are following closely the impact on energy consumption, in effect making this building an energy laboratory.The preliminary results are impressive, indicating energy saving in the range of 55% in comparison with similar conventional buildings.
The new building at CRES is an example of the possibilities provided by the application of current energy technologies in the built environment for the reduction of energy consumption and it complies with all the standards and building regulations in the Regulation on the Rational Use and Conservation of Energy.

Dimosthenis Agoris
President

The bioclimatic office-laboratory building was designed in 1998 by associates of CRES as a demonstration building for the application of energy technologies. Following the call for tenders, construction began in November 2000. The building was completed in July 2001 and in November 2001, regular collection of data began on the building's energy consumption, thermal energy and the performance of the energy technologies.

Topographi diagram of the building (south face variance 15° to the east)

Aim

The design and construction of a bioclimatic and low energy consuming building which would use different soft energy forms and energy saving techniques was the aim of the project. The building includes a large number of systems based on renewable energy sources (RES) and energy technologies for demonstration purposes as well as for monitoring and evaluation of their efficiency. Finally, the researchers in the role of the <user> interact with these systems so that conclusions can be drawn concerning user behaviour which is a very important parameter in assessing the performance of energy technologies.

Building Layout - Use

The building was constructed as a single two storey structure with a basement which includes:

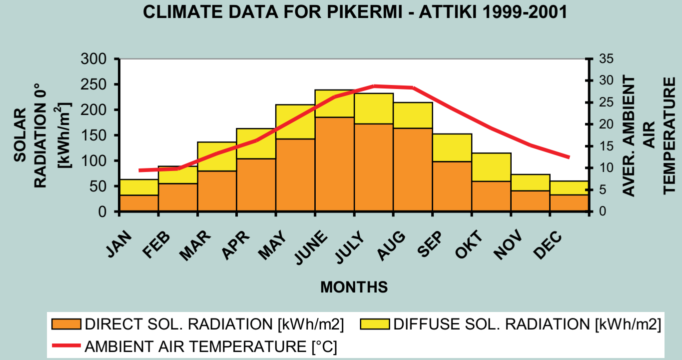
- Offices for researchers
- Library bookstacks
- Small meeting room
- Washrooms
- Small kitchen
- Common areas and corridors
- Basement utility areas
- HVAC unit

Location - Climate

CRES is located 20 kilometres from the center of Athens in the Mesogeia area on Marathon Avenue in the village of Pikermi, an agricultural area with olive groves and vineyards, which has been rapidly built up over the last 20 years.

The location is quite favourable with minimal noise and air pollution. The vegetation around the building does not have an impact as it leaves the south face open to direct sunlight.

The buildings adjacent to the north face and the small trees to the west provide partial protection from cold north winds. The average ambient air temperature in January is 9.4 C and 28.7 C in July. The building is heated from mid-October to the end of April and the degree days for heating are 1217.5 (19 C base).



Construction

The building was constructed according to its design specifications and Greek building regulations.

The building envelope was constructed using reinforced concrete C20/25 with S500 steel. The walls are double brick and the insulation was placed on the outside to avoid creating thermal bridges.

The internal walls are made of drywall(gypsum board), internally insulated with fiberglass(?). The external surfaces were constructed of 3 coats of cement plaster.

External insulation on the north face of the building

Southeast face of the building during bricklaying

The COP factor for the heat pump, if there is solar assistance is 4.8 and the water heat exchanger is of concentric type.
In the basement of the building (the library), two air to air heat pumps of semi-central type have been installed.

Artificial Lighting System

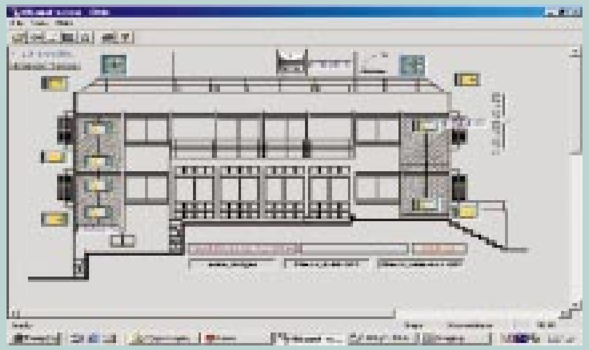
Artificial light is supplied through the general lighting installation of the building which is automatically controlled by the BEMS. The luminaires used have low energy consumption fluorescent pipes or compact PLC type lamps). Ceiling light fixtures have high frequency electronic ballasts, metal lengthwise parabolic blinds and double parabolic elements or ceiling spots with shiny reflectors.

Building Energy Management System (BEMS)

The reason for installing a BEMS was the monitoring and/or automatic control of the building's electrical and mechanical installations so that it will be possible to have immediate access, uninterrupted operation, settings adjustment and data analysis for all the building and system functions from a single control station. At the same time, it is possible to monitor and record the performance of the renewable energy systems installed in the building as well as the creation of an archive of statistical data. The system is based on the EIB (European Installation Bus) communication protocol. The energy management system monitors and controls the following:

- Comfort conditions
- Heating air conditioning system
- Production of chilled/hot water through the operation of a water chilled geothermal heat pump.
- Production of chilled/hot water through the operation of an air cooled heat pump.
- Thermosiphonic panels- solar air collectors
- Greenhouse
- Solar atrium
- Walls with transparent insulation
- Lighting system
- Cooling systems
- Air quality
- Building electricity consumption monitoring

The central control unit and the first floor control board



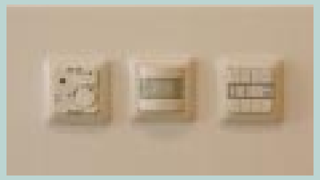
BMS screen which controls the performance of the solar air collectors.

The control system consists of a Central Control and Monitoring Station, the EIB system sensors, EIB command execution devices and connecting cables.. The programming and operation of the system is easily carried out through the central control station. In certain rooms, the operation and selection of different modes is carried out with local controls which have mode options.

The system is composed of independent structural elements which have been selected and connected to each other so as to allow control and monitoring of the building from a central point by computer. The Control Station is connected by a RS232 interface.

The latest digital technology EIB has been use.

The guiding commands are transferred through a pair of twisted reinforced cables from the central unit to the decoders. The system is supplied with low voltage power (up to 24 V).



Room thermostat, occupancy sensor, and eight function switch installed throughout the building's rooms

The decoders have one address and control, either in groups or individually, the control points connected to them. In this way, grouping, programming and control of building parameters is achieved. The pair of twisted cables connects and serves control points (i.e. switches, relays, dimmers, occupancy sensors, etc.) of the installation (beginning at the first connect point and stopping at the final one), without returning, in two ways. It transports communications signals and at the same time it supplies the control points with the low voltage power (24 V DC) needed for them to function. The route of the power cables (230 V AC) is limited to going from the distribution board panel to the electrical loads.
The control points receive commands simultaneously through a common bus without the danger of overloading with the use of the protocol <Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA)>. Each point has a certain address by means of which it is determined if the message transferred on the bus is directed at the point or not and whether the point executes the command or simply receives it without taking action.
Appropriate programmable modules are connected to the bus, such as occupancy sensors, control systems with switches, temperature sensors, daylight measurement system, etc.

User Behaviour problems whisch were Encountered

Due to the many different systems which were installed for demonstration, the building requires systematic monitoring by an energy manager. In particular, maintenance problems were encountered with the automatic controls and controlled devices (relays, filters, etc.) of the well pump. There were also complaints from building occupants who work in rooms facing a site orientation associated with adverse thermal loads because it was not possible to control effectively the room air temperature (range of room temperature adjustment 3.5 C by the system thermostat). Additionally, BEMS computer breakdowns often created malfunctions in the various controlled systems, especially the air conditioning one.

Photovoltaic Panels

On the sloping part of the roof which covers the solar atrium, 12 photovoltaic panels (dimensions 132 cm x 64 cm x 5 cm) were installed with a total power output of 600 W (amorphous silicon), directly connected to the building's electricity supply through an inverter. The inclination of the photovoltaic panels is 20 for architectural and aesthetic reasons, although for maximum yearly output it should be 40 . Also, a solar collector for producing hot water (60 lit) was installed to cover the building's limited needs for hot water.

Economic Analysis

The energy technologies and systems installed in the building cost, in 1999 prices, 11% (39.780€) of the total cost of the building. Based on the results of the first 126 days of energy measurements in the building and on the calculated energy saving (53165 Kwh/year) compared with similar "conventional" buildings, there is a simple payback period of 14.5 years. The payback period would have been much smaller, but because the building was a demonstration project, systems were installed which increased the cost of energy technologies (three air conditioning systems, double number of sensors and actuators for the BEMS, etc.) and therefore, the payback period.

P/V 600W on the sloping part of the roof