Innovative application
- high performance insulation materials
- daylight compensation system
- dfficient HVAC system
- solar PV
- CHP

European Project "Eco-Building International Club for advanced European sustainable energy technology dissemination in Europe and China"

Project partners:
ENEA (IT), ISNOVA (IT), FINCO (IT), ADEME (FR), AIMCC (FR), DTI (DK), DI (DK), CRES (GR), EBHE(GR), GPREC (GR), SEC(B), ZERI (CN), CBEEA (CN)

SIXTH FRAMEWORK PROGRAMME

General information:

Title of demonstration project: BIOCLIMATIC BUILDING OF THE CRES-CENTRE OF RENEWABLE ENERGY SOURCES

- Project developer: BONAIR
- Location (address, Country of technology developer): Irakliou Ave, 350, N. IONIA, GR-14231.
- Project starting date (year):2002
- Project status: Operating

Summary of project:
The heating system of the bioclimatic building of CRES is defined as the entire heating plant including a solar assisted heat pump, the Solar Air Collectors (SAC), and the heat distribution system (comprising the fan coil units). The fraction of the building-heating load covered by the heating plant as well as the solar air collector configuration is assessed in the article, for two modes of operation, the direct mode (warm air from the collectors is supplied directly to the conditioned space) and the indirect mode (air from the SACs or its mixture with ambient air not directly to the conditioned space but into the evaporator of the heat pump).

The technique of the indirect heating aims at maximizing the efficiency of the of SACs, at saving of the electrical power consumed by the compressor of the heat pump and, therefore, optimising the coefficient of performance (COP) of the heat pump due to the increased intake of thermal energy from the environment.
In the context of this article, conclusions will be drawn regarding the influence of the solar air collectors on the building heating load coverage (solar fraction), as well as the degree to which the thermal power offered by the solar air collectors is utilized to heat the building (use factor).
For instance, in an office building, the conditioned space may require only a fraction of the thermal power given by the solar air collectors due to its internal thermal gains. Additionally, since the SAC thermal power output rises at off-peak thermal loads of the building (the peak load is defined as the maximum heating demand of the building), the utilization of the SAC thermal power output is poor, resulting in a further negative impact on the use factor, which decreases. For the purpose to each to conclusions regarding the results of the indirect heating technique, we will use the "Tsagair" computational model for the incident solar radiation, the solar energy absorbed by the SACs and the coefficient of performance of the heat pump, in order to subsequently derive the **solar fraction** and the **use factor**
The obtained results is given in terms of solar assisted COP that reaches, following measurements, up to 3,44 at 4,2 ^{o}C ambient temperature.

Description of project:
- Aims/background
- Situation/opportunity for project implementation
- Technical description (technical principle, including picture and/or technique scheme)
- Performance:
  - Energy data
  - Economic data
  - Environmental data
  - Carbon Dioxide emission reduced

In the bioclimatic building of the Centre of Renewable Sources of Energy (CRES), which is situated at Pikermi, Attiki, solar air collectors, whose surface is 25 m ^{2}, supply hot air to the evaporator of an air to water heat pump (its standard thermal capacity rises up to 16,7 kW, pict.1).
There is possibility of double operation of the air collectors:

- in the hybrid-active operation, the heated air is yield to an air to water heat pump and helps to its evaporator, in order to contribute to a higher heat pumping and, hence, increase the efficiency of the solar heat. This happens because the heated air is unable to cover directly the thermal losses of the spaces.
- in the bioclimatic-passive operation the heated air is supplied directly to the space, in order to cover the thermal losses, when the heated air is in the position to cover directly the thermal losses of the spaces.

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Picture 1: Solar air collectors, 25m2, placed south façade on the bioclimatic building of CRES coupled to a 16.7 kW air sourced heat pump.

In order to apply the operation of the energy system in both modes as analyzed above, we have placed air dampers which control the air flow.

For example, when the internal dampers D_1 are closed, the external dampers D_2 are opened and the system operates in indirect heating mode (hybrid operation, fig.1) while in different damper position (for both D1 and D2), the system operates in direct heating mode (passive operation, fig. 2).

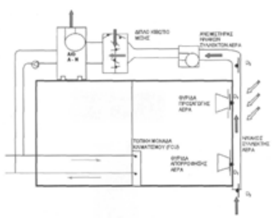

Figure 1: Hybrid operation_indirect heating of the bioclimatic building space

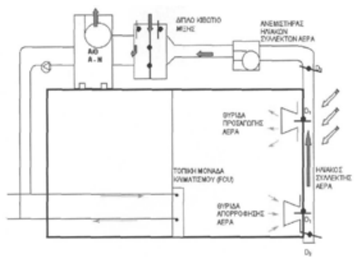

Figure 2: Passive operation_ direct heating of the bioclimatic building space

2. THE HEATING SYSTEM COMPONENTS

The solar assisted heat pump

Generally, the most important characteristic of a conventional air to water heat pump is that it pumps heat from the ambient air.

The disadvantage of the air, as heat source, is its low temperature during winter, which decreases the coefficient of performance of the heat pump ($COP_{H/P}$) while, simultaneously, the space heating needs increase.

Also, another significant disadvantage of the air is its humidity that freezes in the fins of the evaporator coil, so that the air circulation speed decreases increasing the thermal resistance of the evaporator coil due to the ice built.

These two disadvantages of the air, as heat source, become not significant for a solar assisted heat pump, air to water.

For instance, in the bioclimatic building, due to its circulation behind the black paint absorber of the flat plate air collector, connected in row series, the fresh air is heated up to a significant temperature (i.e. from 5ºC up to 12ºC) and then supplied to the heat pump evaporator (fig. 2).

Finally, the heat pump evaporates at a higher evaporation temperature due to the increased ambient heat and supplies more efficient heat to the building by heating up the secondary water loop of the fan coil unit (FCU) network.

The COPh/p of the heat pump is given by the equation:

$$COP_{H/P} = Q_{H/P}(T)/Q_{elH/P}(T) \qquad (1)$$

where: $Q_{H/P}(T)$ = Useful thermal power of the heat pump

$Q_{elH/P}(T)$ = Absorbed electric power of the heat pump

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T = the evaporator air inlet temperature. (i.e. T_a, ^0C)

3. EVALUATION OF SIMULATION RESULTS USING MEASUREMENT RESULTS

3.1 Measurements on the solar assisted heat pump, air sourced

For the *passive operation*, the daily values of the heat pump's useful heat $Q_{H/P}$, the absorbed electric power $Q_{elH/P}$ and the average daily coefficient of performance of the heat pump $COP^D_{H/P}$ are given in table 1.

Table 1. Quantitative results for the heat pump, when the collectors are in passive operation (the H/P operates with ambient air)

PARA METERS	T_a (ºC)	$Q_{H/P}$ (Wh/d)	Q_{elHP} (Wh_e/d)	$COP^D_{H/P}$
DAILY VALUES (4/2/03)	10.2	79851.3	23987.2	3.33
DAILY VALUES (5/3/03)	5.5	21092.8	7976.6	2.64

For the *hybrid operation*, the daily value of the heat pump's useful heat $Q_{H/P}$, the absorbed power $Q_{el\,HP}$ and the average daily coefficient of performance of the heat pump $COP^I_{H/P}$ are given in table 2.

Table 2. Quantitative results for the heat pump, when the collectors are in hybrid operation (the H/P operates with solar air)

PARA METERS	Ta (ºC)	$Q_{H/P}$ (Wh/d)	Q_{elHP} (Wh_e/d)	$COP^I_{H/P}$
DAILY VALUES (21/2/03)	4.2	48546.9	14092.53	3.44
DAILY VALUES (11/3/03)	9.3	24775.7	5012.41	4.94

3.2 Comparison between the simulation model calculations and the on site measurements

3.2.1 Comparison on daily result basis

For the passive operation, the daily value s of the heat pump's useful heat $Q_{H/P}$, the absorbed electric power $Q_{elH/P}$ as well as the positive variation between calculations and measurements Δ_{COP} are given in table 3.

Table 3. Variations between measurements and calculations for the heat pump, when the collectors are in passive operation (the H/P operates with ambient air)

PARA METERS	T_a (ºC)	$Q_{H/P}$ (Wh)	Q_{elHP} (Wh_e)	$COP^D_{H/P}$	Δ_{COP} (%)
MEASU REMENTS (4/2/03)	10.2	79851.3	23987.20	3.33	
CALCU LATIONS	10.2	84323,0	23553,93	3,68	7,5%
MEASU REMENTS (5/3/03)	5.5	21092.8	7976.67	2.64	
CALCULATIONS	5.5	23181,0	7857,97	2,95	11,7%

Eco-Building Club: an innovative RTD&D results' promotion approach

Different from common market promotion approaches, where market operators are only simple message receivers, the project proposes an innovative approach: Eco-Building Club is a virtual round table, around which building market operators will be main actors for market penetration of research and demonstration results, through the following actions:

- determining what are more appropriated innovative RTD&D results for local market transferring;
- demonstrating the feasibilities of the research and demonstration results on real cases.

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All market operators are invited to join Eco-Building Club!

Apart from awareness of most recent EU research results applicable in building sector, the Club offers to market operators:
- an innovative procedure for analysing market potentiality of research results and eco-sustainable building concepts in an international ambit;
- the opportunity for having a qualified and direct contact with worldwide high level experts in building and energy sectors;
- the possibility to promote one's own research results through project dissemination activities;
- the opportunity to assess the feasibility of some specific technology transferring actions.

For the hybrid operation, the daily value of the heat pump's useful heat $Q_{H/P}$, the absorbed power $Q_{elH/P}$, the average daily coefficient of performance of the heat pump $COP^{I}_{H/P}$ as well as the positive variation between calculations and measurements Δ_{COP} are given in table 4.

Table 4. Variations between measurements and calculations for the heat pump, when the collectors are in hybrid operation (the H/P operates with solar air)

PARAMETERS	T_a (ºC)	$Q_{H/P}$ (Wh)	Q_{elHP} (Wh_{el})	$COP^{I}_{H/P}$	Δ_{COP}
MEASUREMENTS (21/2/03)	4.2	48546.9	14092.5	3.44	
CALCULATIONS	4.2	51779,6	12885,4	4.33	16,8 %
MEASUREMENTS (11/3/03)	9.3	24775.7	5012.4	4.94	
CALCULATIONS	9.3	26757,0	5029,0	5,32	7,7%

We observe that the simplified simulation model Tsagair for the assessment of the solar assisted heat pump in the building of CRES presented an acceptable level of variation between the calculations and the measurement results.
This variation can reach up to 16, 8%.

3.2.2 Comparison on seasonal result basis

To achieve model evaluation based on comparison of measurements and calculations with criterion the completion of various integrated sums of energy (within the heating period) is not reliable, since total seasonal measurement results have never been made in the building.
Nevertheless, with scope to experiment the SAC in various operation modes, we have made measurements, at constant parameters, for short time intervals covering for instance two weeks. Moreover, it has become feasible to compare the results of simulation using the program TRANSYS and the ones of the simplified model. The comparison relates to the direct heating (only) and for the heating period. The relevant comparison results of calculations as well as the resulting variatin from the TRANSYS are shown in the table 5.

Table 5. Calculations of parameters and variations between two models of simulation for the entire heating period (direct heating) in the bioclimatic building of CRES on 15th January 2003

PARAMETER FOR COMPARISON	Calculations with TRANSYS 15	Calculations with TSAGAIR	Variation
Seasonal solar radiation	430 kWh/m^2	455 kWh/m^2	+ 5,81%
Seasonal production of solar air	93 kWh/m^2	105 kWh/m^2	+ 12,90%
Total load of two offices (with thermal gains)	1878 kWh	1935 kWh	+ 3,04%
Solar Fraction	86%	94,4%	+ 9,58%

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4. CONCLUSIONS

The technique of the indirect mode of heating has optimised (maximized) the efficiency of the Solar Air Collectors (SAC) and yield to electrical power savings consumed at the compressor level of the heat pump since we have optimised the coefficient of performance (COP) of the heat pump due to the increased intake of thermal energy from the preheated air inside the solar air collectors (see table 2, $COP^{D}_{H/P}$=4.94 against $COP^{I}_{H/P}$=3.33 in the table 1 for two days with about same ambient temperatures).

There exist a transition curve which relates the ambient temperature and the solar radiation on the collector's surface. If the solar radiation on the collector's surface is higher than this transition value, then a direct heating mode is reliable and more efficient.

Against code TRANSYS 15 and when calculating seasonal amounts of useful energy, the model Tsagair presents variations up to about +11%

To conclude, the use of "TSAGAIR" model is considered reliable.

The project received 100% subsidy from the General Secretariat for Research and Technology of the Greek Ministry of Energy.

- Information on project developer

Further information:

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The EBC membership will be established through a specific endorsement procedure by the completion of the endorsement questionnaire.
The questionnaire can be downloaded from the project website: http://www.ecobuilding-club.net/downloads/Technology_developers.doc

- If you would like to be included in the project's 'market operator' database, please fill in the form downloadable at: http://www.ecobuilding-club.net/downloads/Market%20operators.doc