Arfrisol, bioclimatic Architecture and solar cooling Project

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ABSTRACT: The Spanish Ministry of Education and Science (MEC) is promoting a singular strategic project called ARFRISOL which stands for Bioclimatic Architecture and Solar active Cooling. This strategic project plans to save up to 60% office building energy demand by means of passive techniques and reduce conventional energy consumption to only 10-20% of the usual consumption with active solar devices: solar thermal collectors for heating and cooling and photovoltaic panels for electricity.
Five office buildings are to be built or rehabilitated in different climatic zones of Spain.

One of these five buildings is called CIESOL. The advanced state of the building when the project ARFRISOL was planned, limited the application of solar passive techniques, but at least its roof has a large area for solar collectors and place for heating and cooling installations.

The other four office buildings have not begun their building process yet, so they remain at a thinking and pondering stage.

In any case, each project focuses on 3 main points, trying to find new ways of energy saving:

- Climate conditions study.
- Right orientation of the building.
- Project conditions:
    - Passive strategies → (ventilation study, thermal inertia and studying how to compound the different envelope material layers, shading study, etc.)
    - Active strategies → solar heating and cooling, solar electricity prototypes.

This project is continuously held up by energy simulation with the main energy simulation software, and will be monitored for at least a year to see how the building behaves with real use conditions.

Keywords: Bioclimatic Architecture; Sustainable design; Project conditions; Solar cooling, Building Energy Permormance.

1. INTRODUCTION

Since 1975, the Spanish government requires the complement of buildings energy saving, but since 1979, these rules had not change until March, 28 2006, when the new CTE (building technical code) came into effect.

For this reason, energy saving on housing and offices has only been a matter of comfort, not for less consumption or for energy optimization; therefore offices and houses and their building process are consuming a lot of energy in heating and cooling.

A year before the CTE came into effect, CIEMAT, and the Spanish Ministry of Education and Science, with the most important Spanish construction companies (DRAGADOS, OHL, ACCIONA, FCC) and some of the Spanish solar technologic companies (UNISOL, ATERSA, GAMESA SOLAR, ISOFOTON) as well as some research centres (OVIEDO UNIVERSITY, ALMERIA UNIVERSITY, BARREDO FOUNDATION) are working on a project called PSE-ARFRISOL (Bioclimatic Architecture and Solar Cooling), a R&D project involving many professionals from different fields (physics, engineering, architecture, construction, etc…)

They intend to demonstrate that an important part of conventional energy could be saved with a few bioclimatic strategies and the right working process at the very first conception level of the project. After the end of PSE-ARFRISOL, this method and its conclusions could be used as reference by architects and constructors to build efficient energy buildings.

PSE-ARFRISOL is organized in 9 subprojects (SP's), 5 of which are office buildings (Demonstration and Research Building Prototypes– DRBP) in different climate areas of Spain, using different strategies for each place of the Spanish geography and climate conditions. SP2 (CIESOL- office DRBP at Almeria University, Almería, Spain), SP3 (Ciemat

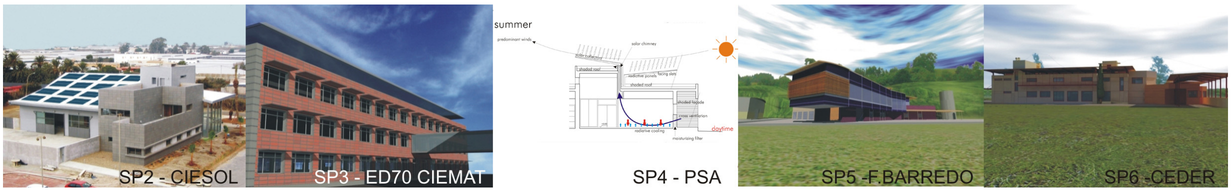

Figure 1. Different Subproject DRBP's

ED70 – office enlargement DRBP, Madrid, Spain), SP4 (PSA – office DRBP at Tabernas Desert, Almería, Spain), SP5 (Barredo Foundation- Office DRBP at S. Pedro de Ánes, Siero – Oviedo, Spain), SP6 (CEDER – rehabilitation office DRBP, Soria, Spain).

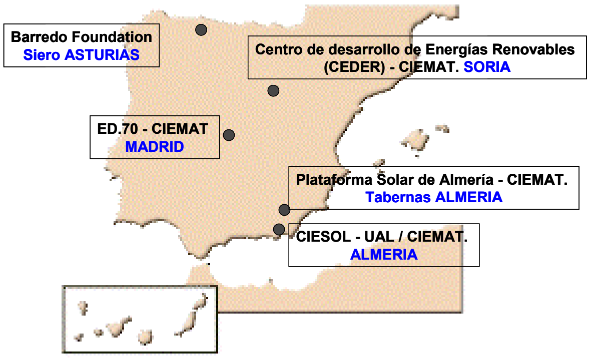

Figure 2. DRBP's Situation Spanish Map

SP1 are previous studies, SP7 monitoring, Sp8 R&D in systems and SP9 spreading.

A very important subject of this project is to verify that each project (building project), carries out all the sustainable design and good construction rules which are vital for a project of this kind.

2. HYPOTHESIS & METHODOLOGY

2.1 Phases

Creating a working method divided into different phases, each building project can be studied with the same structure, and these phases are:

1.- Climate conditions studies
2.-Basic knowledge of bioclimatic architecture given to the architect author of each project.
3.- Interaction among working groups at the very first stage of the project.
4.- Simulation of each basic project with main energy simulation software (TRNSYS, DOE-2, ENERGY PLUS, LIDER, CALENER, ETC)
5.- Improving basic project with complementary bioclimatic strategies.
6.- Simulation of each building project
7.- Improving building project.
8.- Construction process
9.- Design of monitoring process

2.2 Climatic conditions studies

The combined action of place and climate prevents from using standard models of bioclimatic architecture, quite the contrary, it has to be thought really well for each place and climate in order to favour a respectful architecture with the environment and energy efficient. With these parameters, many kinds of architecture can be produced.

In any case there are some standard parameters that can be used for each general climate type as shown on table 1.

Of course, it is necessary to have climate information of the specific place where the building is going to be built, because there are many places that have microclimate conditions, and this is very important to make a good design of the building.

CLIMATE TYPE	STRATEGIES
COLD	Protected hollows from dominant winds. Frames with minimum levels of infiltrations Mobile isolate elements that allow solar radiation during daytime and impede heating loss trough glass areas at night. Semi buried building, which allows reducing thermal oscillations taking advantage of 'cathedral effect' and terrain temperatures.
WARM	Solar protection during overheated time. Direct solar radiation access during under heated time. Night ventilation during overheated time combined with dominant winds protection during under heated time.
HOT DRY	Small hollows to reduce solar access and limit wind penetration. Patios for refrigeration and to allow night ventilation. Fountains and vegetation on patios for evaporative cooling.
HOT WET	Solar radiation protection with leaves or vegetation. Elevated building over the ground to provide ventilation. Building situation regarding to vegetation to impede additional humidity from it. Building with large hollows and very permeable walls with lattice, grille, etc...

Table 1. Strategies Depending on the climate

2.3 Basic Knowledge of bioclimatic architecture.

Basic knowledge of bioclimatic architecture, was basically used on traditional architecture all over the world to satisfy energy necessities before the fuel and electricity era. Architects and constructors had to intensify inventiveness to make buildings comfortable and habitable with only passive strategies. Since the modern architecture movement and the use of fuel, gas and electricity as main energy sources, inventiveness on project design was no longer needed on energy terms, getting rid of passive strategies and overlooking the place, materials, etc... Nowadays with factors such as pollution, CO2 emissions and lack of fuel, gas and necessities of electricity, this kind of design is no longer sustainable, where modern buildings are quite similar all over the world. Nevertheless, since people are used to the current way of life, it is impossible to get rid of these facilities, that is why there is the need to provide solutions to actual comfort standards of cooling and heating, making people aware of real cooling and heating comfort standard needs and how to satisfy them by using only or mostly renewable energies.

The way to get into these concepts, is by getting many different sectors involved in the construction process (politics, architecture, urbanism, construction and of course population, which are finally the consumers) aware of the importance of simple things like orientation, climate conditions, comfort sensation, materials, solar energy, ventilation, etc...

In many places people are used to being indoors during winter time with the heating system at 24ºC, just wearing a T-Shirt, instead of being at 18-20ºC and wearing a sweater. On the other hand, in the summer people have their cooling systems at 20-22ºC and wearing a long sleeve shirt, instead of being at 26ºC wearing a T-Shirt. These behaviours do not make any sense, because they are a waste of energy, regardless of the kind of energy being used. So this is a very important subject to make society aware of.

2.4 Bioclimatic architecture strategies during project process

Passive strategies.

Passive strategies are those which only use natural conditions to reduce heating and cooling necessities, and therefore energy consumption, without using any machine. There are many known passive strategies, some of which are at a research process in this very moment. Mainly, passive strategies are:

- Taking advantage of climate conditions of the place.
- Orientation of the building to take advantage of solar gain.
- Different treatments for each façade.
- Patios.
- Humidity treatment.
- Right choosing of isolation materials and width of them.

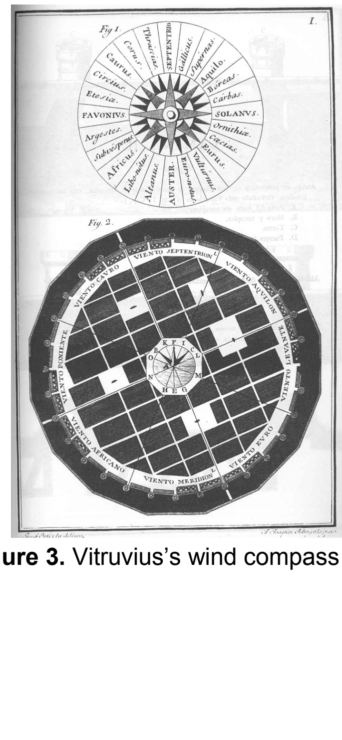

Figure 3. Vitruvius's wind compass

- Natural ventilation (simple and cross ventilation).
- Solar chimney.
- Inertia walls & Ventilated façades.
- Natural lighting
- Shadowing.
- Greenhouse effect.
- Buried pipes for cooling.

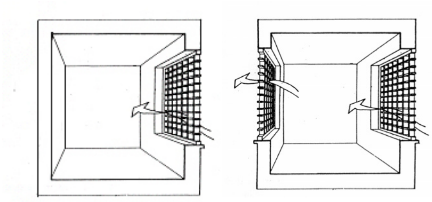

Figure 4. Natural Ventilation

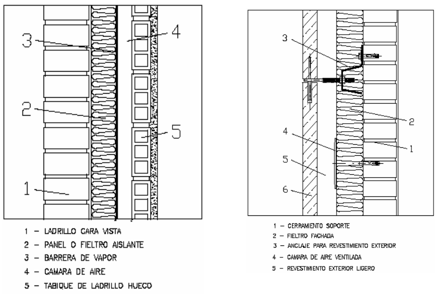

Figure 5. Wall types - inside isolation vs. Outside isolation.

Figure 6. Experimental Solar Chimney – J.Martí-Herrero (LECE - CIEMAT)

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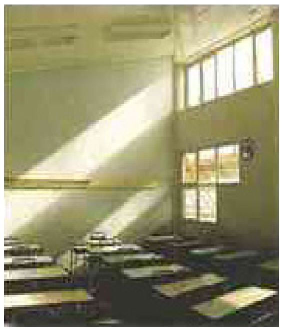

Figure 7. Correct Natural lighting.

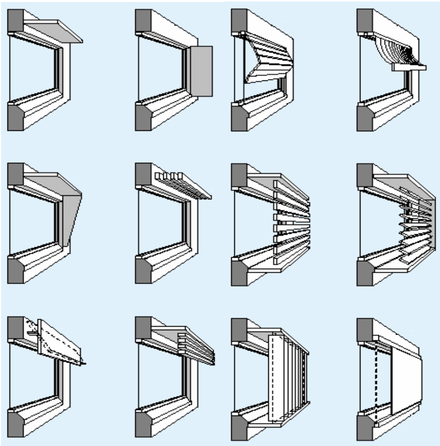

Figure 8. Shadowing methods

Figure 9. Greenhouse effect.

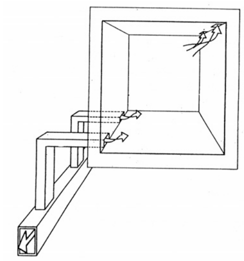

Figure 10. Buried pipes.

Active strategies are:
- Thermal solar collectors.
- Forced ventilation.
- PV panels.
- Absorption pumps

2.5 Project process

As a starting point, before designing the building, is compiling information of the traditional architecture of each place, observing how the buildings are situated on the place, hollow sizes, wall thickness, materials, etc… it is a method to get ideas to use on the project design.

With these first ideas begins the basic project process. The very first design must consider bioclimatic architecture and sustainable design tasks. Different façades for each orientation, different hollow sizes, optimization of thermal isolation on each façade, natural materials from the place, use of non pollutants materials, etc.

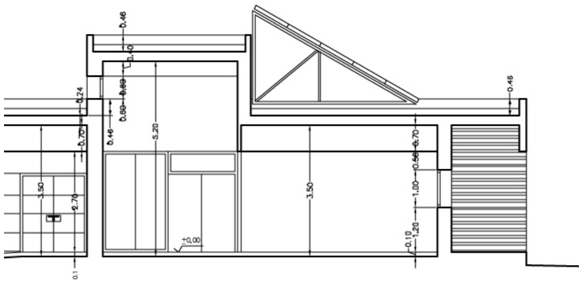

Figure 11. SP4-PSA Basic project cross section.

Once the basic project is ready, with a vague idea of the materials that will be used, begins a bi-directional work between the architect and the simulation researchers, who propose some hypothesis of simulation in order to obtain different results and share this information. This proves that improved project energy demand is less than the one demanded on the basic project, letting the architect choose between a range of solutions to make the design more accurate. These results can be for example, enlarging or reducing wall thickness, changing wall layers' order, changing shading area, changing materials, improving windows' glasses and frames, promoting natural ventilation systems, and many other strategies, that can be forgotten at the basic project design.

At this point begins the building project process that consists of capturing all the ideas of the previous stage and putting them all together on a project. It is now when the energy demand is known by using only passive strategies. These data come in the installation project, trying to complement the rest of the energy demand that it is not supplied by passive strategies with active strategies, solar heating (thermal collectors) and cooling (absorption pumps), solar electricity (PV panels) and other renewable energies if possible.

With the construction of these DRBP's, it is the time to design the monitoring project and finalize the Hypothesis and Methodology to get into demonstration.

3. MONITORING & DEMONSTRATION

3.1 Monitoring

This process consists of laying out different types of sensors through different parts of the building according to the monitoring design, to demonstrate that software simulation related to the building behaviour at a real condition of use verifying the energy saving predicted with simulation is real or very close to reality.

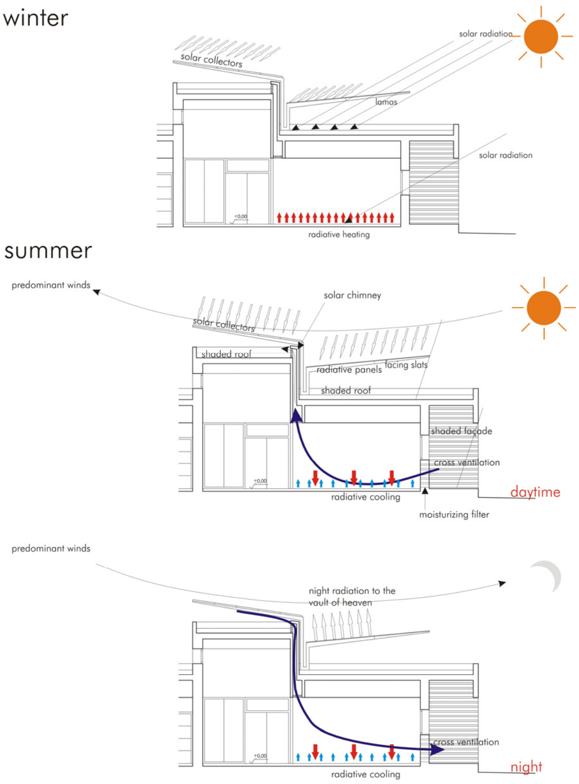

Figure 12. SP4-PSA Improvement proposals cross sections

3.2 Demonstration

After a year of experimentation collecting data, the workgroup will be able to demonstrate how close reality is from simulation, and this will be useful to accurate each simulation model for future references. This is the most important part of PSE-ARFRISOL, the comparison between simulation and reality over 5 projects spread all over Spain.

4. RESULTS

As the project is at its first stage, only simulation and improvement recommendations of each BRDP have been made, so there are no available results to present yet. Examples of SP4-PSA recommendations are shown on figure 12.

The most advanced subproject (SP2 – CIESOL), which is already built, is getting into the monitoring design phase, so that the workgroup would not be able to present results for at least a year.

Also along PSE-ARFRISOL, solar technology companies will have to improve their prototype machines to develop them as a final product at the conclusion of the project after four years.

5. CONCLUSION

PSE-ARFRISOL, will be the first research project that checks the relationship between simulation and real condition of use energy demand of an office building, improving if necessary the simulation model to make it more effective, saving up to 80 or 90% of conventional energy use.

PSE-ARFRISOL, also involves R&D of different solar prototype elements and machines.

The project will make society aware of the importance of bioclimatic architecture, energy saving, spreading news of the project and teaching basic knowledge at schools, high schools and universities.

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