Casa Ecologica: Warmer at low cost in winter, colder at no cost in summer

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ABSTRACT

In 2001 two twin residential buildings were erected in Milan, each hosting around 50 apartments on 6 floors. They both have adopted eco-friendly and energy efficiency solutions, but there are also some differences among them. This paper presents the main findings of a comparison between the energy performances of the two buildings during winter and summer seasons, showing that although the look is absolutely similar and the differences in the design are limited, they have an impact that cannot be neglected.

1. CASAECOLOGICA & BOVISA90

In 2001 two twin residential buildings were erected in Milan, each hosting 54 apartments on 6 floors, a total volume of around 35 000 m^3. They both have adopted eco-friendly and energy efficiency solutions, among which wall and floor insulation with cork stronger than prescript by the Italian law, but there are also some differences among them.

The CasaEcologica project was developed by a cooperative of people gathered together to build a new house. These persons were all inhabitants of Bovisa, a district in Northern Milan, now hosting the new premises of the Politecnico. During the ’80 they were all involved in different NGOs, all active to improve the living condition of their part of the town.

Bovisa was a highly industrialized territory, hosting factories, gasholders, railways deposits and terminals. Green zones were limited and of poor quality.

When these people had the need of buying a new house, they decided to promote a cooperative project, with environmental and social added value. The basic choices included in the articles of association may be synthesised as follows:

- the building should be well integrated in the urban framework of the district and the city;
- no green area should be harmed or wiped out
- healthfulness and well-being of the inhabitants should be assured
- only natural resources and materials, can be utilised, they should be renewable and recyclable
- the use of scarce or polluting resources must be minimised
- the project should favour good social relationships among inhabitants.

In order to have the necessary economic resources, they decided to melt with another cooperative, that was less interested in environmental issues. This result in the decision of designing two buildings, similar but different.

The two cooperative got together to buy an industrial area: one third of it was intended to host the residential buildings and two third of it an equipped area for children.

The change in the urban plan was difficult to obtain, resulting in almost ten year of delay in the project. Finally in 2001 the buildings were finished and handed over.

2. DESCRIPITION OF THE BUILDINGS

2.1 Building envelope

Each of the 108 apartment has windows on both sides: in the CasaEcologica Building they are towards north and south, in the Bovisa90 build-

ing they are towards east and west. This is aimed at favouring, or at least not impeding, natural ventilation. All houses have balconies, blinds and external curtains. Balconies are almost two meter broad, being an important shadowing device during the summer season (Fig. 1). Windows are double glazed, with wooden frames.

2.2 Heating system

The main difference between the CasaEcologica and the Bovisa90 buildings is the heating system. CasaEcologica is served by a condensation boiler with radiating panels in the floor, while Bovisa90 hosts a high efficiency boiler with traditional radiators.

All houses are equipped with control systems, regulating set temperature and time of functioning. Regulation can be different for working days and weekend days.

The sanitary hot water instead, is supplied by a centralized boiler, with tanks that can contain 10 000 litres of hot water. The boilers room is placed under the roof, facilitating a possible solar heating integration (see paragraph 6).

Heat counters take account of the actual heating and sanitary hot water consumption. The heating bill is 80% proportional to the actual consumption, giving a strong incentive to save energy to the occupants.

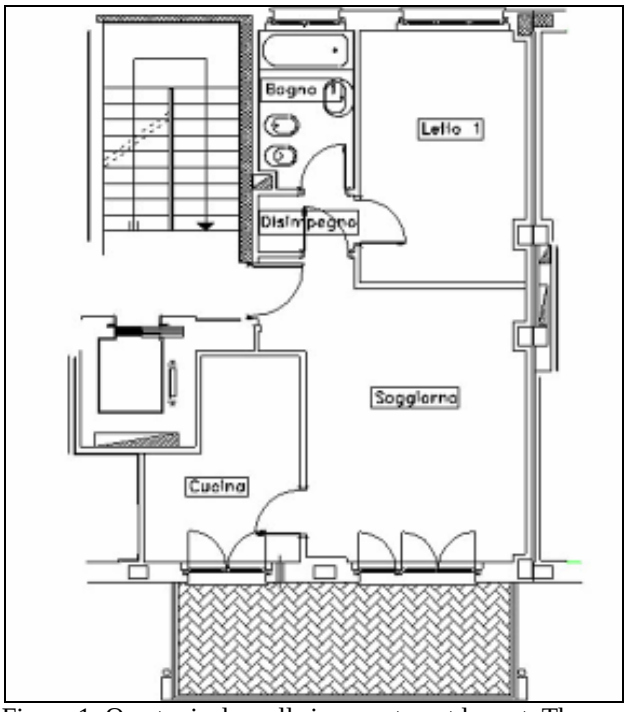

Figure 1: One typical small size apartment layout. The grey area represents the balcony

3. WINTER HEATING CONSUMPTION

Heating consumption was monitored during winter season 2002-2003.

Considering space heating the CasaEcologica building specific consumption was 48 kWh/m^2 while Bovisa90 specific consumption was 65 kWh/m^2. Sanitary hot water consumption was around 15 kWh/m^2 on average for the two building.

The maximum theoretical heating requirement established by the national regulation for buildings located in Milan's climatic zone is around 110 kWh/m^2. The proposed building energy performance certification in Milan province would assign a class B to building with heating requirement less than 50 kWh/m^2 (class A to building with heating requirement less than 30 kWh/m^2).

Considering the two buildings the CasaEcologica shows a 26% saving that can be explained by three factors.

First of all, the different orientation: in winter season the sun is lower on the horizon. During the central hours of the day the rays may enter through the windows of the CasaEcologica that are on the south facade. This passive solar contribution is very important. In days when the sun shines, even if the outside temperature is relatively low, the apartments keep an internal temperature of 20-21°C, while the heating system is off. Bovisa90 having windows only towards east and west, cannot beneficiate from this advantage.

The second important factor is the heating system. CasaEcologica hosts a condensation boiler with radiating panels in the floor. The temperature of the water flowing through the panels is around 25-30°C giving to the condensing boiler the chance to work in the best conditions.

A third important factor may be the awareness of the inhabitants. As already seen, the CasaEcologica founders are more conscious of the environmental impact of the energy consumption and more motivated to decrease it. Actually only ten to twenty family are founder members, while the remaining twenty to thirty joined the cooperative later in time, just for the need of a house. The contribution of this third

factor may be debatable.

4. SUMMER COMFORT CONDITIONS

While the verification of the energy performance during winter is quite simple, when it comes to the summer we cannot just compare the energy bill. The only difference between the two buildings that should play a role during summer is orientation, since the building envelope shows no differences. In particular we expect that in the CasaEcologica building better conditions should show up.

Wide balconies towards south, all equipped with external curtains, completely shelter the apartments during the central hours of the day, when the sun is southward and high on the horizon. The air along the south facade should also be warmer, and should move up. When the windows are open in both the north and south facade, the temperature gradient will therefore originate a natural ventilation, with colder air coming from north through the apartment. Will this natural breeze, without any active system intervention, have any effect?

Bovisa90 is on the contrary exposed towards east and west. Even if the balconies and the curtains are similar to the CasaEcologica ones, they cannot hinder the sun rays.

In order to measure the actual differences originated by the orientation, we must be careful that no other factor should influence the measurement campaign. It was necessary to identify similar apartments in the two buildings, in which we can expect that the only difference was the orientation. The selection was carried out during spring 2004 analysing questionnaires filled in by 87 families (on 104 total).

Ten apartment were selected (five in each building) so as to identify couples of apartments that were similar in:

- size,
- number of occupants,
- time of occupation, during the day or during the week
- habits in the use of passive cooling systems (curtains, rolling shutters, windows)
- absence of active cooling systems.

In each of the ten apartment the temperature and humidity were monitored from May to October 2004. We distributed to the ten families involved in the project a questionnaire to record their comfort sensation, using Fanger's PMV scale (vote between +3 and -3, when 0 corresponds to comfort conditions, positive numbers with hot conditions and negative numbers to cold conditions). The vote should be expressed around eight p.m. when most of the occupants should be present and we expect that the temperature conditions would be the most critical.
Families were asked also to take track of the days during which the house was not occupied, and the inhabitants were somewhere else.

4.1 Critical days

During summer 2004 general thermal comfort conditions were met in most of the days. We selected the most critical days analysing the outdoor temperature. For each day we considered hourly maximum temperature, minimum daily temperature and average daily temperature. The most critical days resulted to be 9 to 12 June, 27 to 29 June and 17 to 23 June.

In these periods, hourly maximum temperature is higher than 30°C, minimum daily temperature is higher than 20°C and average daily temperature is higher than 25°C.

This intervals result to be the most critical also when calculating the mean vote expressed by the families involved in the project. During these critical intervals the mean vote resulted to be around one, while during the rest of the project the mean vote is around 0.2.

In order to perform a consistent comparison, among the critical days, we only considered those days in which all the ten apartments resulted to be occupied: 8 to 11 June and 19 to 23 July. In the following paragraph and in Figures 2 and 3 we compare the average hourly temperature of the two buildings, calculated as the average measured temperature in the apartments included in the campaign.

4.2 Indoor Temperatures: 8 to 11 June

During the critical days in June, external temperature is on average 26.5°C, reaching a maximum of 31.8°C at 2 p.m. Considering internal temperature, we expect that late afternoon hours should be the most critical ones, due to the thermal inertia of the buildings and to the fact that most of the occupant were present and in activity (e.g. preparation of the dinner) increasing the internal thermal gains.

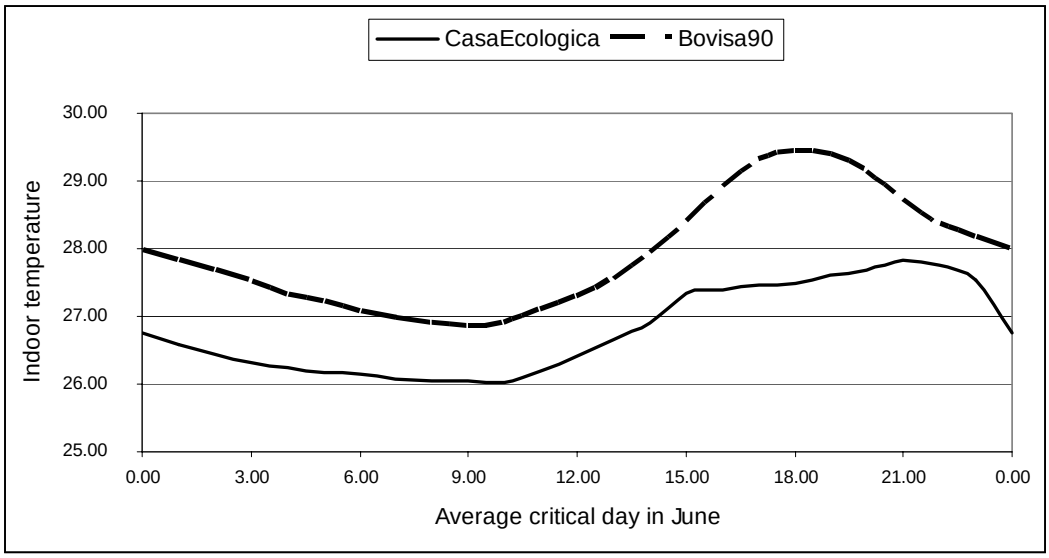

Figure 2: Indoor temperature trend during critical days in June.

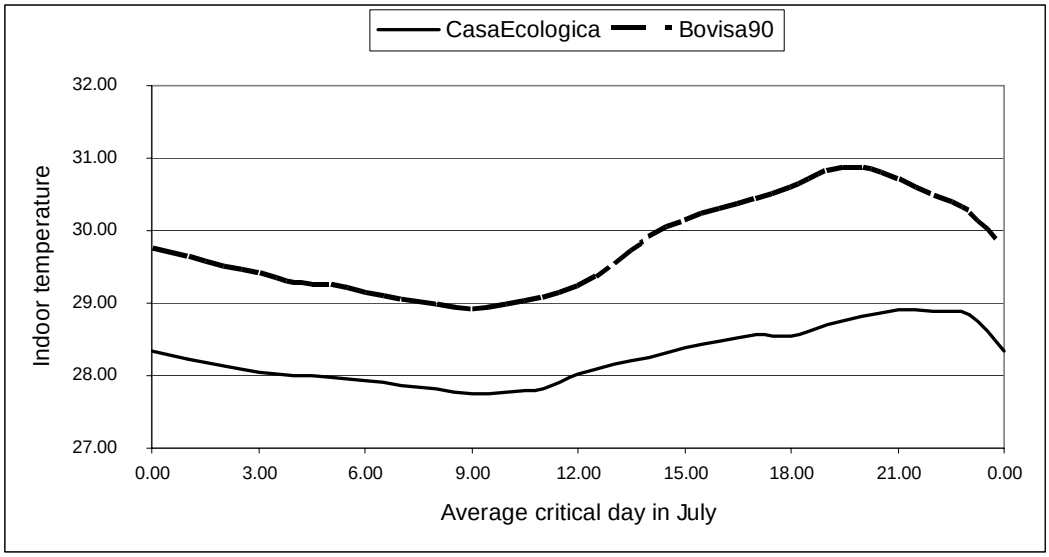

Figure 3: Indoor temperature trend during critical days in July.

In the Bovisa90 building indoor temperature is higher than 29°C between 5 and 9 p.m. In the CasaEcologica building temperature is always lower than 28°C. The difference is on average 1.1°C while the maximum difference is 2°C at 6 p.m.

4.3 Indoor Temperatures: 19 to 23 July

During the critical days in July, external temperature is on average 28.6°C, reaching a maximum of 32.7°C at 2 p.m.

In the Bovisa90 building indoor temperature is higher than 30°C between 3 and 11 p.m. In the CasaEcologica building temperature is always lower than 29°C. The difference is on average 1.5°C while the maximum difference is 2.1°C at 7 p.m.

5. SATISFACTION OF THE OCCUPANTS

The questionnaires utilized for the selection of the apartments to be included in the analysis, contained also some questions about the general satisfaction of the inhabitants of the CasaEologica. The results were quite positive:

- winter comfort conditions: more than 85% of the answers were positive, more than 60% were strongly satisfied,
- summer comfort conditions: more than 90% of the answers were positive, 70% were strongly satisfied,
- all the inhabitants participating to the poll are proud to live in a eco-friendly house and would suggest it to other people.

Figure 4: The CasaEcologica (left end) and Bovisa90 (right end) buildings.

6. ECONOMIC SAVINGS AND COSTS

In the CasaEcologica building families have an annual energy bill of around 250 € for space heating and 230 € for domestic hot water. The Italian Energy Regulator (Autorità per l'energia elettrica e il gas) considers an average family paying around 900 € per year for space heating and domestic hot water. Considering that Milan is in a colder climatic zone than the Italian average, we may estimate that the families living in CasaEcologica have an annual gas bill which is half of the average.

In the warmest days the difference in the internal temperature increases the comfort of the inhabitants, or lowers the consumption of the active air conditioning systems where installed.

In the CasaEcologica some energy efficiency measures were adopted also for public lighting. The annual electricity bill for the lighting of the garages and of the stairs is around 2000-2500 € lower than those of similar buildings.

7. WAY FORWARD

The sanitary hot water system is already well-designed for a simple integration of a solar thermal collector. Recently an Energy Service Company has proposed to install a 200 m^2 collector that should reduce the bill for sanitary hot water of around 35%. The ESCo will be responsible for the design, installation and maintenance of the system. The proposal is considering a third party financing strategy: the inhabitants will not contribute to the investment. The proposed contract will last 12 years during which there will be an annual payment of a fixed quota: if gas prices will continue to increase that will originate economic savings.

After twelve years the system will be handed over to the inhabitants.

8. CONCLUSIONS

Although the energy performance of the CasaEcologica in Milano is good it may not be the best possible, but this is a very interesting experience for a number of reasons:

- it is maybe the first case in Italy were a typical residential building for a urban area hosting around 100 apartments adopts energy efficiency design and concept,
- the design options adopted have originated energy and economic savings, with simple technologies and solutions, that were passive in most cases: the simplicity is a key success factor,
- the environmental friendly strategy does not limit itself to the construction phase, but involves ongoing activities inside the cooperative (to increase people awareness) and in public events (to disseminate and reproduce this success story),
- the project, until now, has received no public funding,
- the costs for the apartments were around 1500 € per square meter, while the market prices in the area was around 2300 €.

But, in the opinion of the authors, one of the most significant key factor for the success of the CasaEcologica is the nature of the process: a particular bottom-up approach.

A group of middle-lower class citizens have decided, by their own initiative, to find one pos-

sible sustainable living strategy. Thanks to the help of professionals they could translate their ambitions in practical design decisions.

The cooperative itself shows to be a good working instrument, helping the cohesion and the learning process of the future users that were involved throughout the design, having the responsibility to choose between different technologies and strategies.

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