# Analysis of passive solar systems of Norman Foster's EDF Building, Bordeaux

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## Abstract

In the regional headquarters of EDF (Electricité de France) in Bordeaux, designed by Foster and Partners and built in 1996, the HVAC (Heating, Ventilating, and Air Conditioning) system and the façades form an ensemble aiming to ensure an efficient thermal behaviour.

The design of the louvers that protect against solar radiation is optimized according to the orientation of the façades. In addition, the building has a centralized computer system for the management of HVAC installations and a series of automation and control sensors supporting them.

A computer analysis of the louvers is made, in order to assess the suitability of the selected design to achieve the energy saving targets proposed by the architects.

The site visits and interviews with users allowed us to know their level of satisfaction with the implemented energy-saving systems and with the performance of the entire building.

## 1. Introduction

In the regional headquarters of EDF (Electricité de France) in Bordeaux, designed by Foster and Partners and built in 1996, the HVAC (Heating, Ventilating, and Air Conditioning) system and the façades form an ensemble aiming to ensure an efficient thermal behaviour.

The design of the louvers that protect against solar radiation is optimized according to the orientation of the façades, so as to achieve a reduction in the energy consumption that is necessary to maintain the comfort conditions of the workers. In addition, the building has a centralized computer system for the management of HVAC installations and a series of automation and control sensors supporting them.

The HVAC system was very innovative at that time (1996). It integrates 6000 points for data collection in a computer network. The management of the temperature and humidity is supported by data supplied the previous day by their own weather station. The aim was to ensure a 40% reduction of the energy needed compared to similar buildings.

## 2. Analysis of incident solar radiation on the façades with and without louvers

### 2.1 Description of the louvers

The louvers are a key element of this building both for its image, and for their contribution to its thermal behaviour. According to Norman Foster, their design took into account the orientation of the façades and the different radiation conditions that occur throughout the year. As a result, the louvers are different for each façade.

#### 2.1.1 East façade

*Fig. 1: East Façade (detail)*

*Fig. 2: Maintenance corridor*

*Fig. 3: Reflective tray*

The east louvers are divided horizontally into three parts. Vertically there are three panels made with a very dense pattern of horizontal wooden bars of circular section. Each panel is slightly turned to the plane of the façade.

There is a maintenance corridor between the façade and the louvers. This corridor is covered by a stainless steel tray that reflects natural light into offices across the diffusing glass situated on the top of the windows.

#### 2.1.2 West façade

The west louvers are horizontal. There are divisions that match the vertical jambs of the windows. This façade also has the maintenance corridor and the reflective tray.

*Fig. 4: West façade (detail)*

### 2.2 Analysis of the louvers

To analyze the real influence of the louvers, solar radiation data on clear days is needed. Due to the complexity of calculating the mentioned radiation, we used the extraterrestrial solar radiation data that is much higher, for not considering the mitigating effect of the atmosphere. Since the analysis is done in comparative terms, qualitative but not quantitative, we have considered this data appropriate.

For each façade we analyze, inter alia, the following two cases:

- Average daily solar radiation incident on the windows.
- Shadows cast by the louvers on the windows.

The calculations have been made exclusively for the direct solar radiation incident on the windows; it was not considered either the diffuse radiation or the reflected radiation from the ground. We have studied only the portion of the window that is protected by the louvers, we have not considered the diffusing glass that is exposed.

### 2.2.1 East façade

The analysis of the average daily solar radiation leads to the following observations:

- The chart for the window with louvers shows that from May to August (summer time) the incident radiation is lower than during spring and part of the autumn. This complies with one part of the architects' aims: reduce heat gains in summer.
- In addition, the incident radiation is equally low in November, December and January (autumn - winter). It was intended to achieve certain gains for free space heating during cold periods but this is not achieved.
- Comparing both charts (a window with and without louvers) it is showed that the louvered window receives less radiation: 72% less during the winter months and 88% less in summer. This excessive reduction of the incident radiation during the winter results in a small use of the radiation for free heating.

The study of cast shadows show the surface percentage of analyzed element which is in shade for each hour of the day.

- The percentage of shadowed surface in the louvered window is higher during summer (92%) than during winter (80%). During the autumn and winter the louvered window has a lower proportion of area in shadow than in summer.
- The window presents, on average, lower shaded area in November but still 76% of its surface remains in shadow.
- Throughout the year the maximum incidence of the sun occurs early in the morning, this incident radiation is very flat and annoying to users.

### 2.2.2 West façade

Analyzing the average daily radiation incident along the year in the louvered windows, it does not appear that its design allows for a higher incidence of radiation during the colder months.

In summer, this type of louvers reduces by 80% the incident radiation. In winter the louvers block the whole. The louvers avoid radiation in the summer but its design does not adequately respond to winter conditions.

Regarding the shadows cast by the louvers, due to the orientation of this façade, the sun comes into contact with the façade late in the day and for a short period of time. In summer the area that is in shade (91%) is lower than in winter (99%).

In general, a proposal that would contribute to improve the performance of the façades would be to change the characteristics of the louvers:

- Mobile louvers in pitch or yaw, and even removable would make better use of the available solar radiation when needed.

- It would also be desirable to reconsider the geometry of the louvers, i.e. placed in an upright position are more suitable for the east and west orientations.

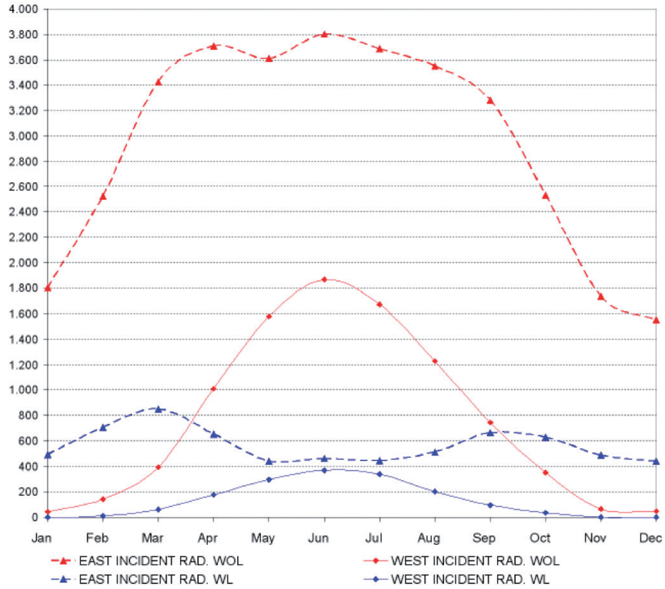


*Fig. 5: East and west façades. Chart comparing the average daily radiation ($Wh/m^2$) incident on a window with and without louvers.*

## 3. Actual operation of the building: 14 years of user experience

The building is in service since 1996 so the user experience is critical in this analysis because, regardless of the outcome of the simulations, it offers arguments to determine the effectiveness of the implanted systems (passive and active).

The building has various types of shortcomings related to the maintenance of the façade, the operation of the automations, the air conditioning, the performance of the installations and the lighting, among others. All this leads to costs that cannot be offset by the savings produced by the passive energy-saving systems.

**The façades:** The louvers and the panelling of the façade are made of red cedar wood. The wood requires annual maintenance to keep in good condition. This expenditure was not foreseen in the project.

To prevent condensation on the interior side of the façade and the structure more ventilation is needed than that required by mandatory regulations. This represents an additional expense, because a greater volume of air has to be air-conditioned.

The users evaluate positively the usefulness of the reflective tray on cloudy days, but on clear days it produces a lot of glare that makes difficult working with computers. The workers' union has filed a formal complaint on this ground.

The forced ventilation takes air directly from the façades through grilles. These grilles require high maintenance due to the cleaning that is necessary to ensure adequate air flow under appropriate hygienic conditions.

**Free cooling:** The automatic opening of windows was scheduled during the summer nights so as to cool the offices. This system had to be abandoned because the moisture spoiled paper documents and computer equipment.

**The HVAC system** is what causes more problems and creates more maintenance costs. HVAC management is centralized for ease of control. Due to its complexity, an outside company performs daily the schedule of the system. This represents a substantial financial cost.

The method of regulation, concerning the parameters of the weather station, makes that the necessary changes in the system for rapid climatic variations can not be implemented until the next day.

The HVAC system does not adequately respond to the peaks or sudden temperature changes. As a result, the air conditioning systems of the building are inadequate and need to be compensated with additional equipment.

The HVAC system is controlled in groups of five offices. If the window of an office is opened, automatic ventilation stops in the other four. Likewise, if one of the offices needs more heat or cold the HVAC system does not respond until the five demand its support in the same way. In the case of small offices, users should be able to individually control the air conditioning.

## 4. Conclusions

To achieve real sustainability, it should be considered from the design stage to the demolition of the building. It should be assessed whether the reached bioclimatic solutions lead to other drawbacks that eventually produce costs that cannot be compensated.

It is possible that the variables of the physical behaviour of the building and the façades have not been valued correctly, so the bioclimatic benefits are not achieved. The behaviour of the building has not proceeded as expected in the project, so the goal of sustainability has not been attained.

During the visits to the building, the users and the responsible for the maintenance of the building stated that they would not do any reforms, they simply would move to another building.

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