Energy-efficient Social Housing: Residential Building in Madrid

Architect:
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1

Selected data:

Completion: 2004
MUFA:
3,939 m^2 residential
251 m^2 retail
GSA: 6,420 m^2

GRV: 15,740 m^2

Heating energy requirement:
62.52 KWh/m^2a
U-value flat roof:
0.32 W/m^2K
U-value wall:
0.43/0.58/0.77 W/m^2K depending on orientation, buffer effect of projecting components is not included
U-value window:
2.18 W/m^2K
U-value floor:
0.45 W/m^2K

The social housing project in San Fermin, an emerging district on the periphery of Madrid, won the 1999 competition for one of three buildings with a focus on "social housing with a high degree of energy efficiency." The competition was initiated by the Empresa Municipal de la Vivienda (EMV Community Housing Development Agency). The brief called for concepts pertaining to bioclimatic planning in multi-story buildings with integrated active and passive use of solar energy. Despite subsidies provided by the EU for any additional costs resulting from ecological and energy-efficient measures, cost-efficiency and proof of operating efficiency for the solar systems were to enhance the model character of the project.

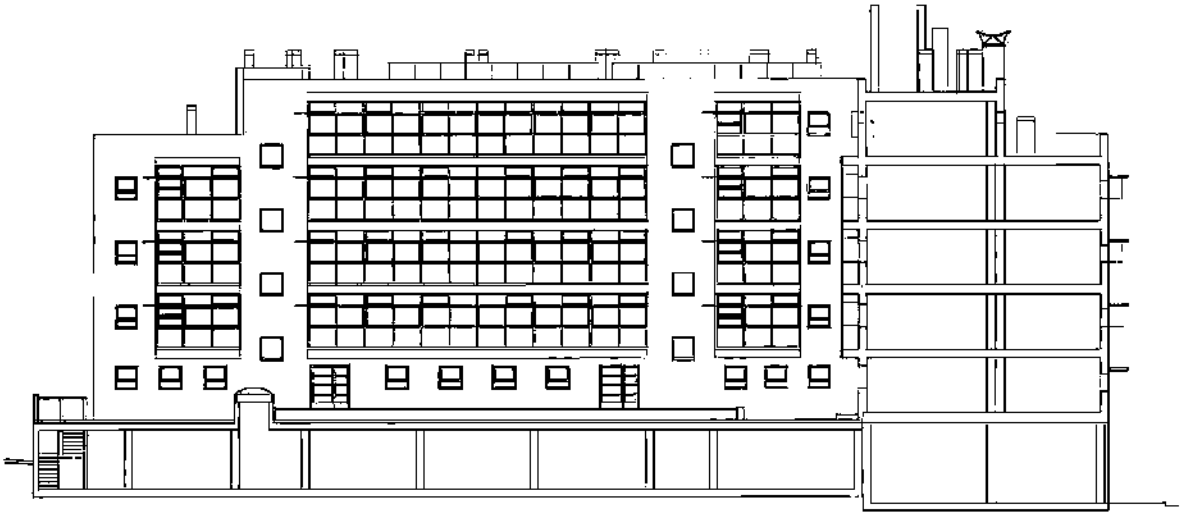
The building adopts the existing U-shape in the extremely dense development with two parallel north-south blocks linked by one east-west block.

To the west, the block is complemented by a higher, neighboring slab, which protects the complex and especially the courtyard against the noise from a six-lane traffic artery.

Parking for the entire complex is provided in an underground garage, which is lowered into the ground by only half a story and receives natural light through a skylight in the courtyard. Due to the natural slope of the site, the east side of the story provides space for retail units at street level. Raised on top of this plinth, the 4-story structure with a recessed attic story accommodates a total of fifty-four apartments.

In addition to the use of solar energy in winter, shading and natural ventilation during Madrid's hot summer months were essential criteria for the planning and construction concept of this building. Both criteria are fulfilled with constructional means and in the arrangement of the apartments within the plan.

The units are oriented toward two sides to ensure cross-ventilation. Within the three sides of the U-shaped development, the apartments are arranged in a differentiated manner according to orientation: living spaces are located on the south or west side, while bedrooms face north or east.



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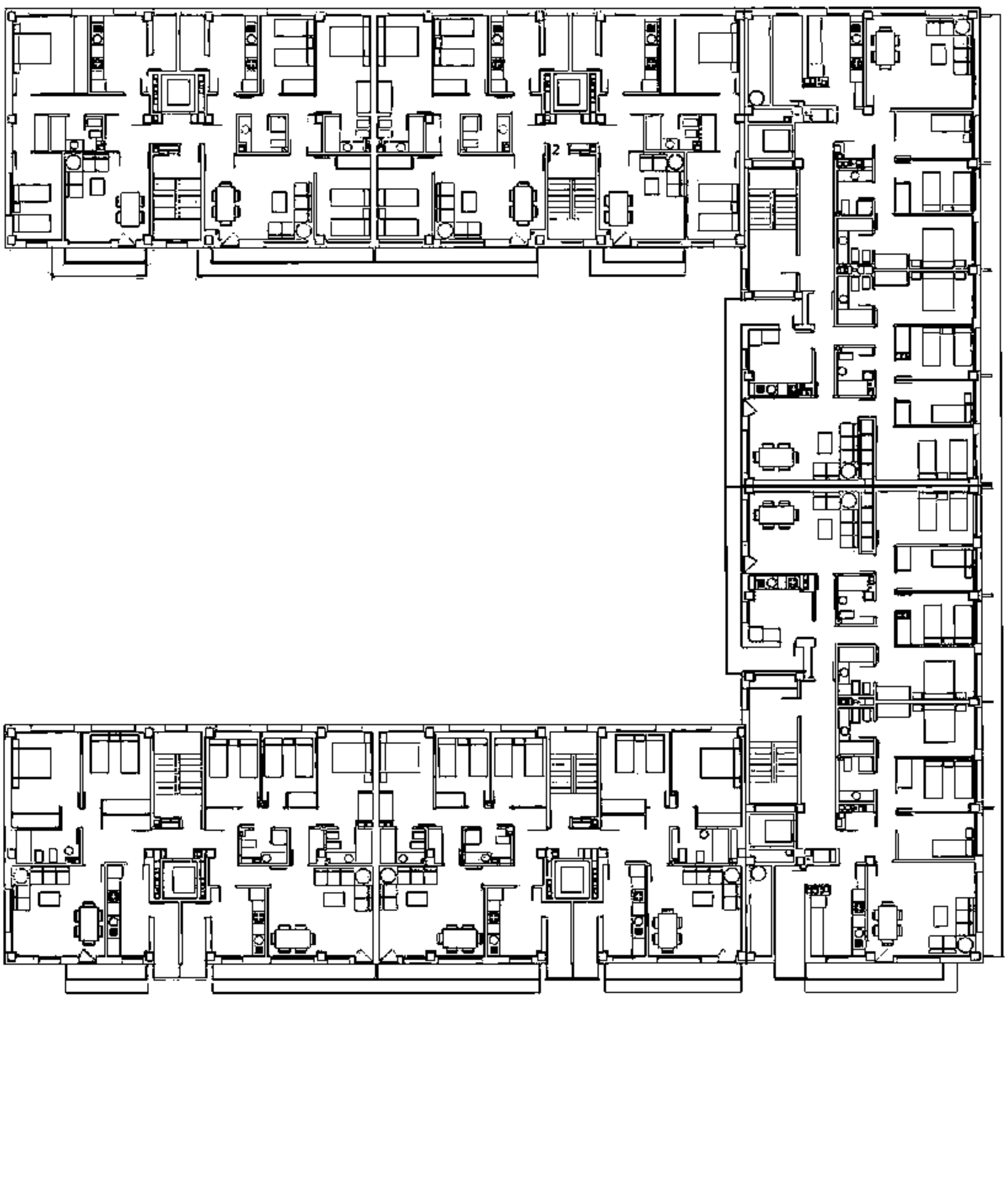

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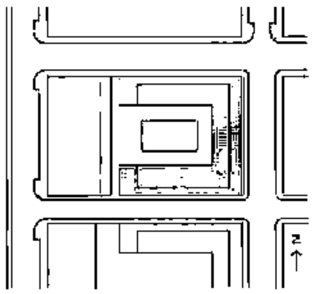

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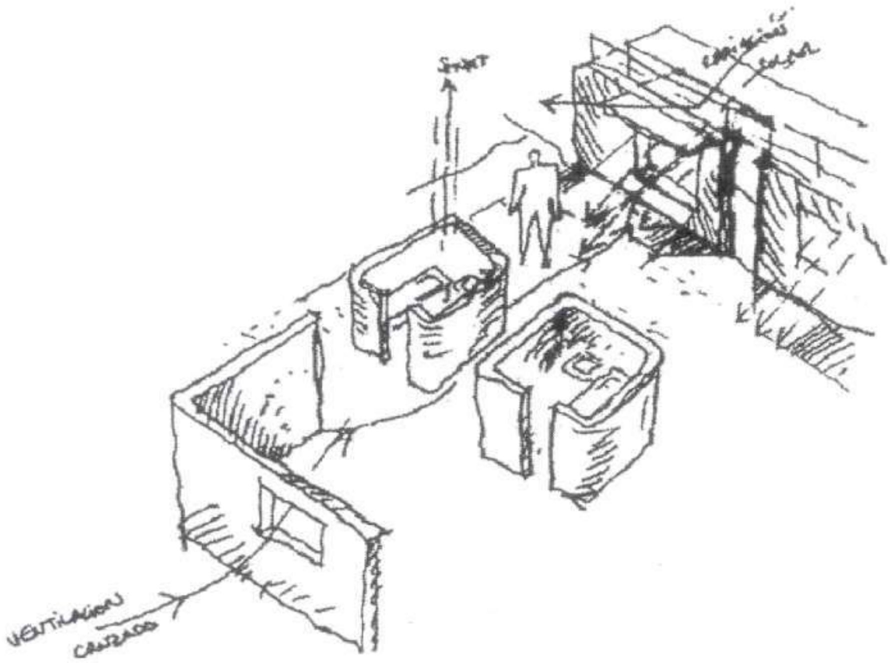
1 Bird's eye view: the high density of the area gives it an urban character.

2 Section – south elevation (courtyard)

3 Floor plan upper story, not to scale

4 Site plan with surroundings, not to scale



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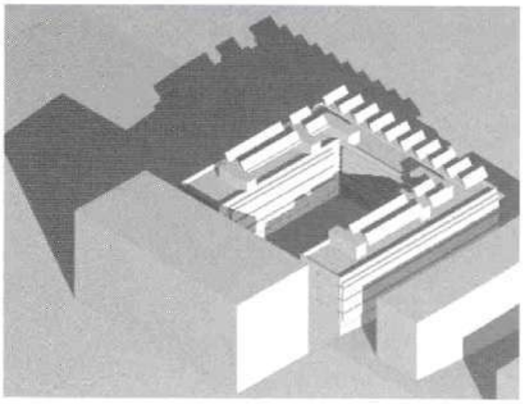

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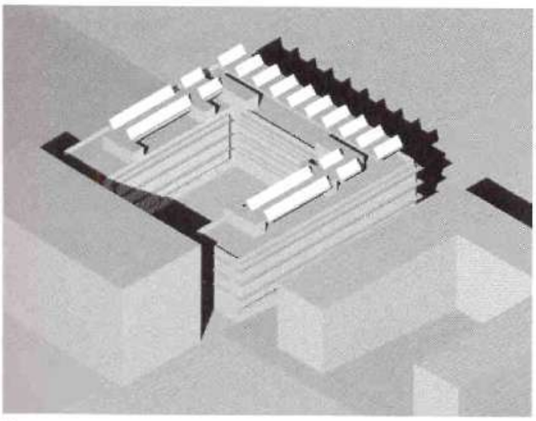
The building service installations form cores at the center of the apartments, a layout that makes it possible to achieve an optimum building depth. This centralized placement of the installations also allows for the shortest possible distribution for supply and disposal.
Different opening dimensions and the systems provided for solar gain and shading give the facades a varied appearance – always according to orientation and location, and according to sunshine or shading conditions. These variations enliven the rather severe block development and serve as an attractive visual expression of the bioclimatic initiatives.

The courtyard is landscaped with local plant species chosen to improve the microclimate, especially in summer. Irrigation of the plants in the afternoon cools the outside air by means of evaporation. This factor plays a key role for natural ventilation in summer. It enhances the effect of both the cross-ventilation in all apartments and the convection ventilation provided via solar shafts.
Ventilation shafts in the central core provide cooling for the apartments with east-west orientation. As a result of the Venturi effect, air is extracted from the living spaces through the roof, while fresh air from the courtyard flows through the windows into the apartments.
The sum of all these measures resulted in energy savings of over 40 percent and half the CO_2-emissions by comparison to conventional buildings that meet the established standards.



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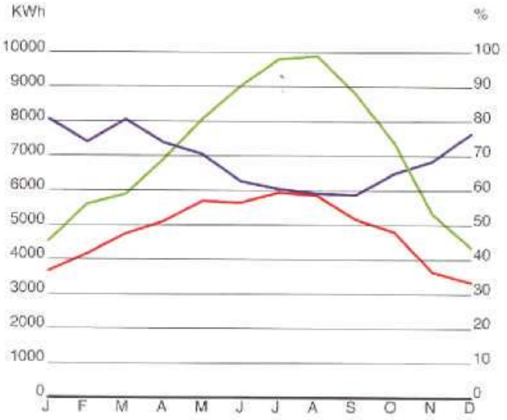

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5 Functional diagram of cross-ventilation

6 South elevation (courtyard) with glazed balconies and external horizontal shading (fixed).

7–8 Insulation/shading studies

9 Energy gain from collectors (KWh, red), warm-water requirements (KWh, blue) and average percentage of supply covered by the system (%, green)

10 Roof elevation with south-facing solar collectors; shading on west facade (courtyard) provided with folding shutters with adjustable louvers

Heating is provided from a central gas boiler operated in modular fashion. Distribution is conventional, by radiators with individual thermostats in each unit. The heating system is computer-monitored and operated.
Transfer stations with meters are housed in cabinets designed for this purpose next to the entrance doors. The meters can be read from the outside to calculate individual consumption.
A second, also gas-operated boiler is used for warm-water processing, supplemented by a solar system comprising twenty-four collectors, each covering an area of 2.5 m². The collectors are installed on the flat roof at a 40° angle and face south. The system covers roughly 70 percent of the total warm water requirements and has a calculated amortization rate of 12.4 to 9.5 years, depending on the projected costs for the conventional energy sources. The energy contribution of the system translates into a reduction in CO_2-emissions of nearly thirteen tons.
Like the openings, the exterior walls are also designed in response to orientation. On the east and west sides, they are designed as single-skin walls composed of thermal insulating, lightweight and porous brick. On the south and the fairly solid north side, the walls are fitted with an external thermal insulation layer. The buffer effect of the glazed balconies was not taken into consideration in the calculation of the overall energy balance.
In the interior, the solid construction form supports the storage capacity required to compensate for temperature peaks in summer. All

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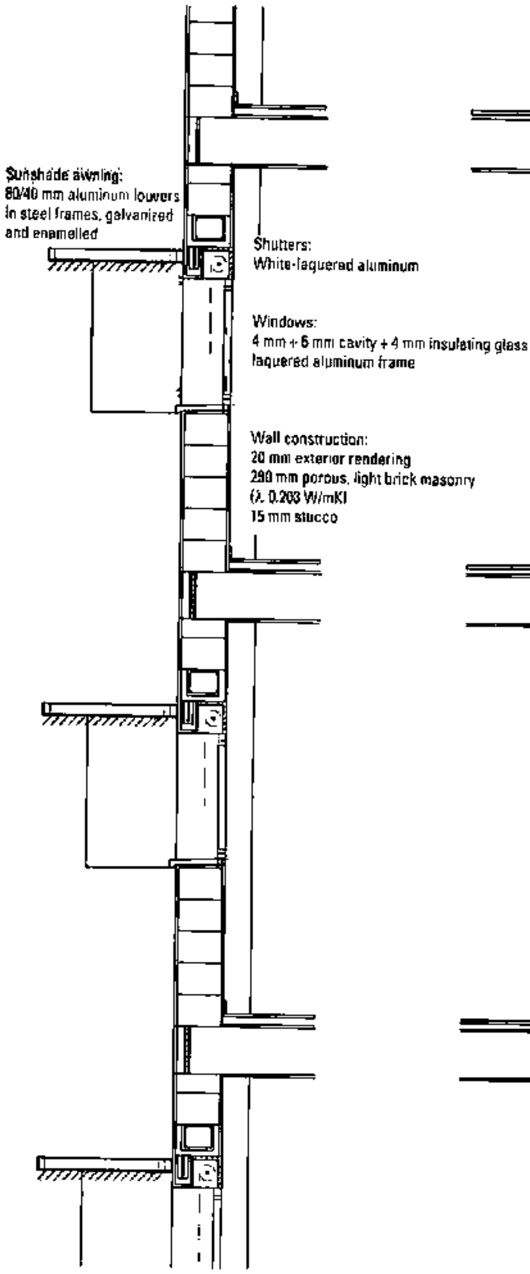

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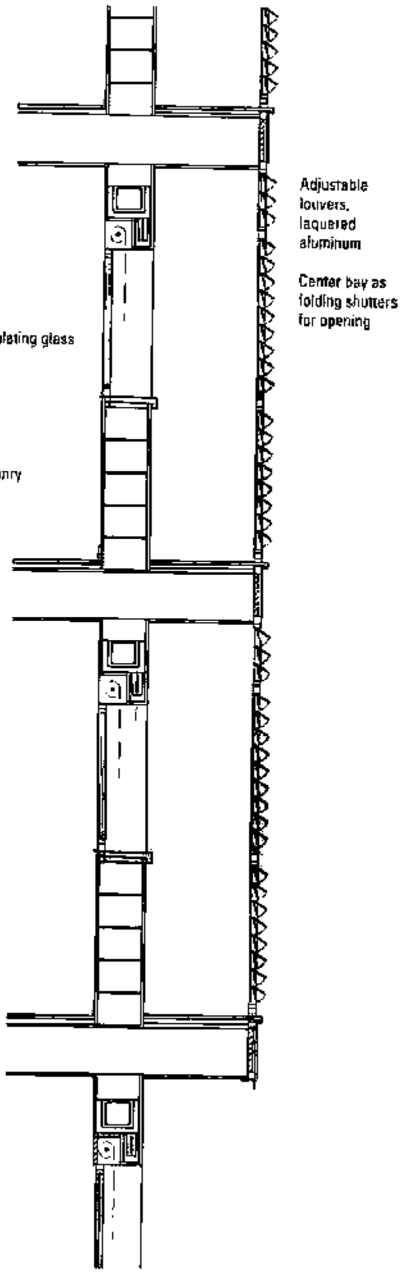

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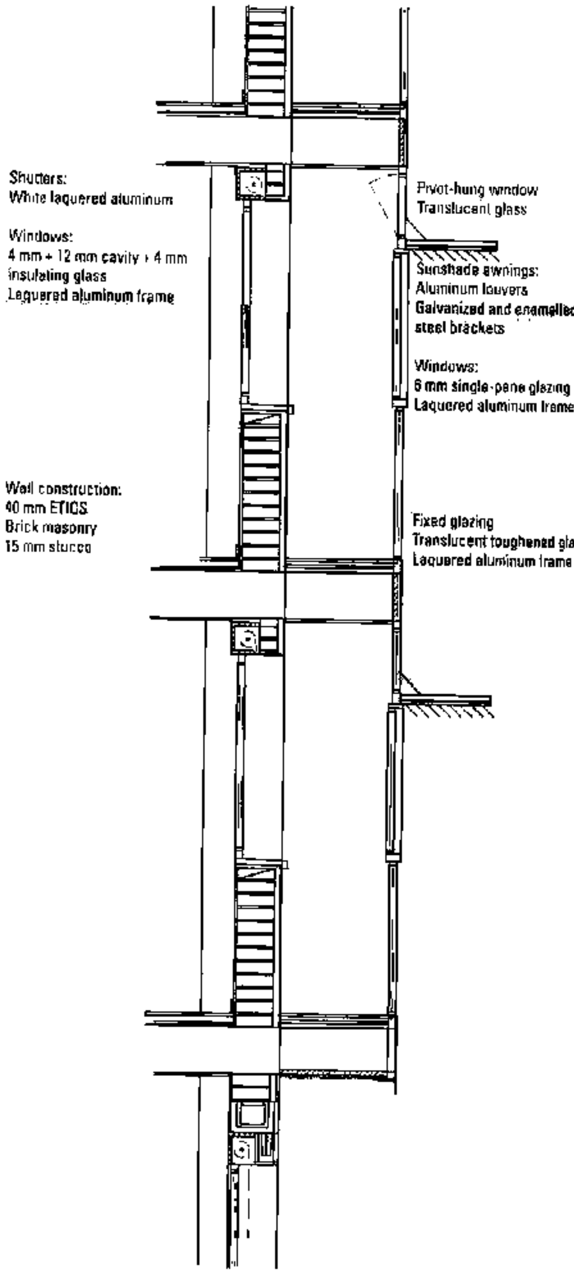

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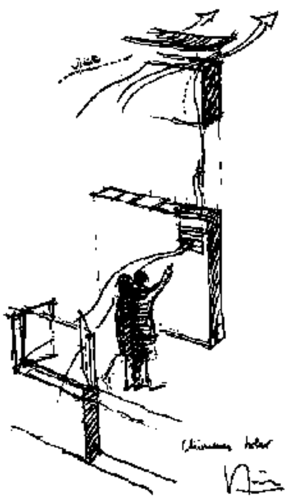

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11 Detail section east facade
12 Detail section west facade
13 Detail section south facade
14 Functional diagram of ventilation with solar stack

openings are equipped with shading elements, specifically designed according to orientation. These elements allow sunshine to penetrate into the interior when needed or, conversely, to block it, an essential feature given the extreme conditions in summer. It is important to note that the shading elements do not diminish the efficiency of the natural ventilation. The south-facing balconies, with translucent glass panels in the parapet area, are designed to act as sun-traps. Horizontal louvers provide shading in summer on this side.

Folding shutters with horizontal, adjustable louvers protect the west-facing balconies against the low evening sun during the hot season. Bedrooms facing north and east feature smaller windows, whereby the east-facing windows are equipped with shading in the form of fixed horizontal and vertical elements.

The systems require very little maintenance and are easy for the residents to operate. Since their functions are clearly designated and recognizable, there is no risk of incorrect use.

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15 West elevation (courtyard): facade with shading by means of folding shutters and adjustable louvers

16 East elevation (street): smaller opening with combined horizontal and vertical shading

17 Functional diagram of shading systems in front of balconies on the west side (courtyard)