Retrofitting of University Dormitories
City Vert-Bois, Montpellier, France

1 Photos

Figure 1. South view of the building after retrofitting.

2 General

2.1 Project Summary

Year of construction:	1968
Year of retrofit:	2003
Total floor area (m^2):	2485
Total heated floor area (m^2):	2289
Number of housings:	166 before retrofitting and 120 (studios) after retrofitting
Area of each housing:	10 m² before retrofitting and 15 m² after retrofitting
Occupied hours:	12 to 13 hours every day (18h – 8/9h).

The University campus of Vert-Bois was built in 1968 in Montpellier and features six buildings in a green park, close to the University Paul Valery. The six buildings are identical in same structure. Oriented north-south, they had 166 rooms and collective toilets before retrofitting.

In 2003 the bathroom accommodations (washbasin, toilet, and shower) were reconfigured into the rooms, and the facades and roofs were also renovated. The new facades will not require heavy maintenance (except periodic new paint) for years. This case study focuses on Building D of the University City, where rooms were transformed into studios in 2003.

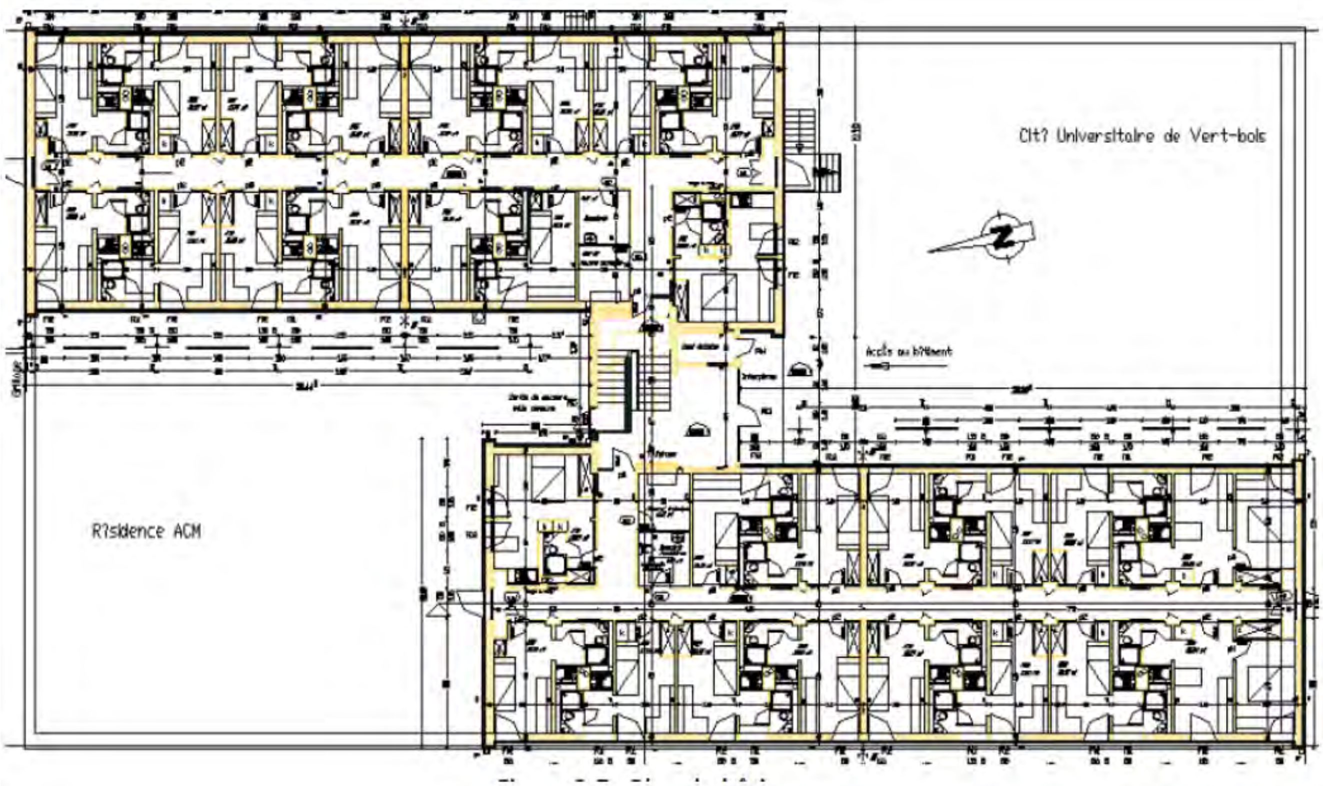

Figure 2. First floor (2 blocks).

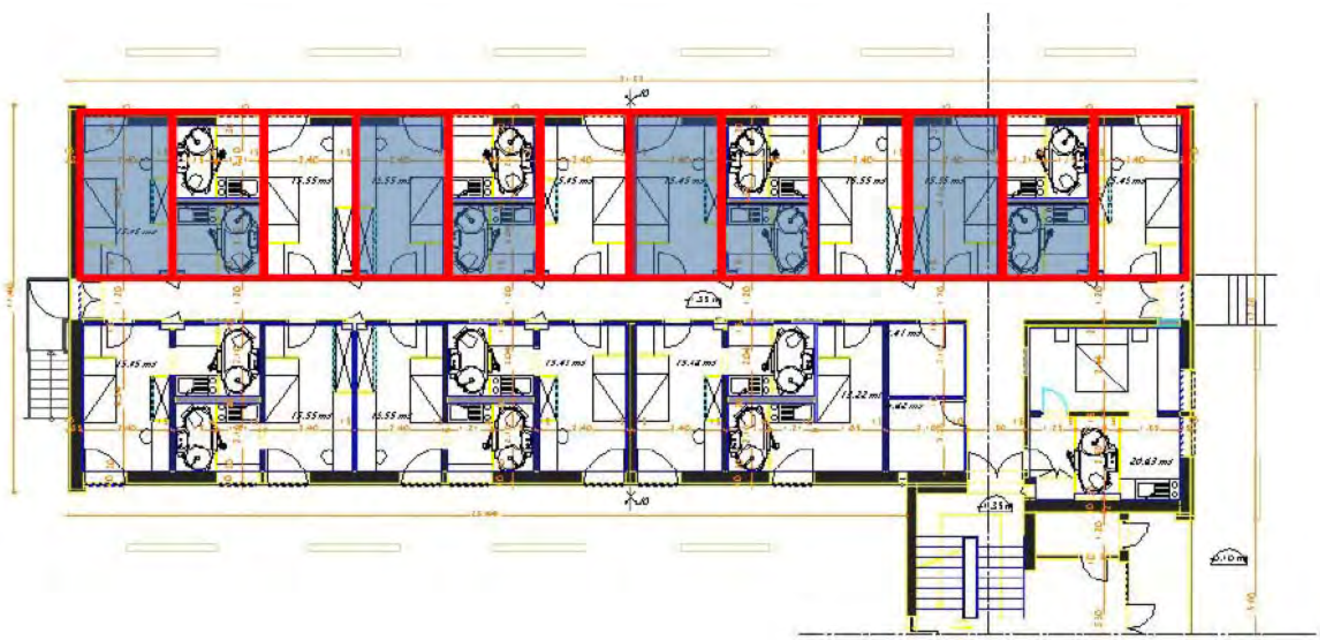

Figure 3. Indoor distribution in a floor (East block).

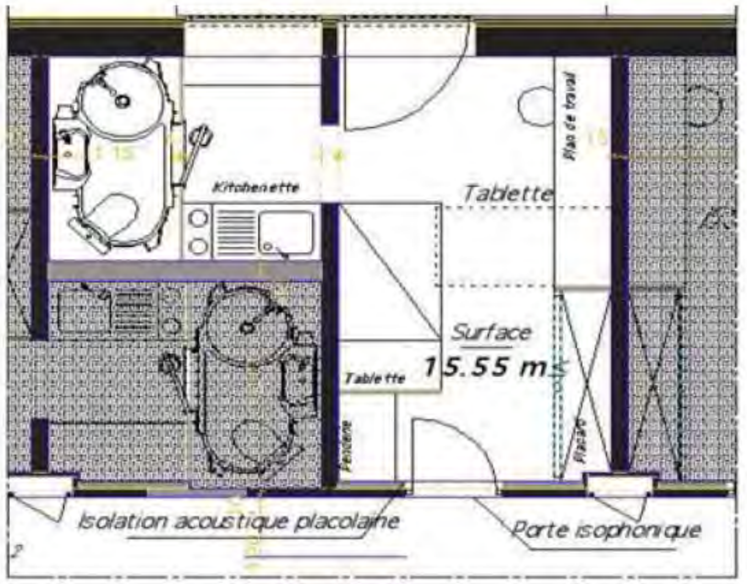

Figure 4. Floor plan of one housing unit.

3 Site

3.1 Site

The university dormitory Vert-Bois is located in the north of Montpellier, in the southeast of France.

Latitude	Longitude	Altitude	Mean annual temperature	Minimum average temperature	Maximum average temperature	Heating Degree Days
43.4 degrees N	3.5 degrees E	70 m above sea level	14.2°C	9.3°C	19.1°C	1841 (base 18°C)

3.2 Typology / Age

The main function of Building D is that of a student dormitory. The building consists of two blocks (east and west), with a common stairwell. The building has four floors, although the west block has an additional half-floor.

Figure 5. View of dormitories before retrofitting.

In 2001, a decision was made to retrofit the building. The initial project aimed to redistribute the internal building spaces to increase the size of dwellings; 166 rooms with areas of 10 m² each were transformed into 120 studios of 15m²; kitchen areas and bathroom blocks (shower, washbasin, and toilets) were configured into each studio. This retrofit was undertaken with a “green” approach to environmental quality, with two main purposes:

- to improve the indoor comfort of the occupants: thermal (summer and winter), visual and acoustical
- to minimize the impact of the building on the environment, mainly through energy and water savings.

4 Heating/Ventilation/Cooling and Lighting Systems Before Retrofit

Before 2003, the building had two sources of energy: electricity and gas. Heating and domestic hot water were provided by two gas boilers of 337 kW each. The central control depends on the outside temperature. The local control is regulated by thermostatic valves on the radiators. The heating thermostat is set to 20°C in winter.

Air ventilation is a simple ventilation flow with a renewal rate of 0.6 vol./hour. Thermal insulation was poor due to the simple glazing and un-insulated walls (consisting of plaster, 30 cm of raw concrete, and a coating). Also, the east-west orientation of the building is unfavorable to summer comfort since it receives the morning and evening sun. (The west orientation is source of overheating late in the afternoon.)

5 Retrofit Concept

Outside insulation (10 cm thick) with a metallic cladding was added to cover the building envelope. A low- emissivity double glazing was also installed. Several different approaches were taken to reduce overheating:

- Outside terraces with vegetation were added.
- Solar protection was incorporated.
- Simple thermo-mechanical ventilation was installed.

In each housing unit, artificial lighting is provided by three wall luminaries equipped with energy-saving 13W lamps, placed on the front door, at the entrance of the kitchen, and at the head of the bed; and by three fluorescent tubes for the desk, and two of 18W in the bathroom and on the kitchen washbasin. The lighting power ratio is 7.5 W/m^2.

Exterior glazed surfaces (windows) were enlarged to take advantage of natural lighting, and the inside walls in each housing were painted in white.

The acoustical insulation was improved by providing double walls and soundproofed doors. (This achieved an acoustical decrease of 30 dB.)

The following low energy devices were installed:

- compact fluorescent lamps
- lighting timers in the corridors
- low energy refrigerators
- new gas boilers.

Low water consumption equipment was installed:

- thermostatic mixer taps (for washbasins and showers)
- faucet aerators for washbasins
- pulsed shower heads
- toilets with a double capacity flush (3/6 liters).

This retrofit project provided an opportunity to install renewable energy technologies. Solar collectors (indirect type with forced circulation and external heat exchanger) provide energy for domestic hot water. There are four hot water tanks: three with 1000 liters of storage, one with 2000 liters. Photovoltaic panels (48 modules) were installed; generated electricity is used directly in the different dormitories on the university campus.

Figure 6. Outside insulated envelope.

Figure 7. Solar collectors on the roof.

Figure 8. Photovoltaic panels.

6 Heating Results

Gas is the only source of energy for heating and production of domestic hot water. The energy consumption meters are common with all the buildings of the university campus. However, the invoices and the energy optimization of consultancy society provide consumption information. Before rehabilitation, the energy consumption of the building (for heating, hot domestic water and cooling) is estimated at 200 kWhep/m².year, and after rehabilitation, 55 kWhep/m².year (energy primary). An accurate assessment of energy consumption of the building requires the implementation of metering.

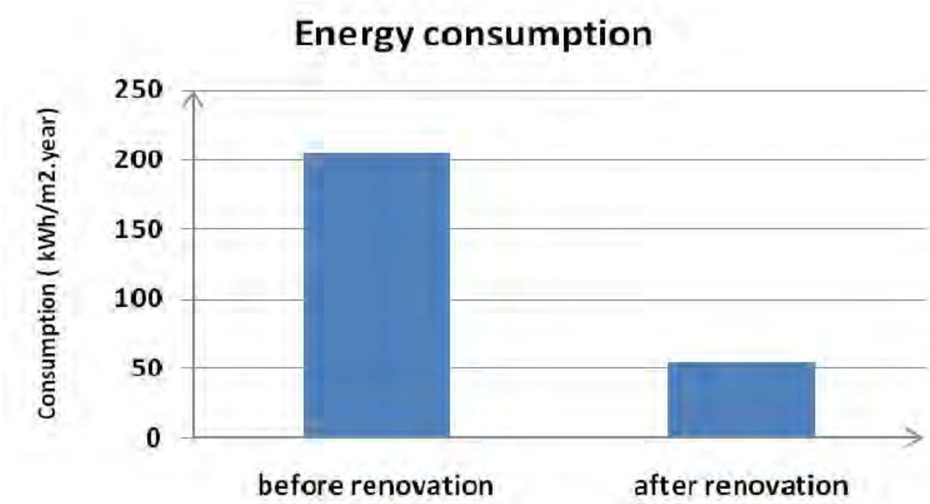

Figure 9. Evaluation of Energy consumption.

7 User Evaluation

Based on a questionnaire and surveys done in May 2008, it was found that:

1. The indoor air quality is considered "medium." CO_2 measurements taken in different studios were satisfactory (between 300 and 500 ppm). However, indoor air is never perceived as very fresh and some students noted significant moisture in their apartments. Students the building's temperature in summer as too warm.
2. Students are still slightly disturbed by ambient noise, especially by conversations in the neighborhood and by outside noise. The sound pressure levels are measured, inside the studio apartment, closed windows and doors, being between 25 and 30 dB, which is satisfactory.
3. The lighting in the building, while perceived as uniform, non-glare, and fairly stable, is often considered too dark. Lighting is generally considered "average."
4. Indoor illumination, whether in natural or artificial light, is perceived as "average." Some studios are poorly exposed, which reduces natural lighting. The vegetation on balconies and walls can block natural lighting. Students on the ground floor appear to be most bothered by poor lighting.

8 Renovation Costs

Total cost:	2,027,877.00 €
Total cost per studio apartment:	16,898.98 €
Financing:	
State and Regional endowment:	1,640,994.00 €
Loan (4.13%, 15 years):	213,000.00 €
Subsidies (ENR, etc.):	133,466.00 €
CROUS:	40,417.00 €

9 Lessons Learned

Some practical experiences of interest to a broader audience include:

- The total insulation of the envelope of the building, including outside insulation, and insulation of roofs and floors, significantly reduces heating needs.
- Still, the total building insulation without a thermal regulation strategy of the envelope (hybrid or natural ventilation, external solar protection, bioclimatic techniques) generates a risk of overheating in summer.
- The vegetation of the facades and balconies requires continuous maintenance, but helps to shade the building from the sun and can improve summer comfort levels in inhabited areas.
- The building's east-west orientation makes sunscreens necessary and increases the need for artificial lighting in the morning and evening.
- The larger windows permit natural the sun's light and heat to enter during the winter, and reduce the need for artificial lighting and heating.
- This heavy renovation provided an opportunity to develop solutions using on-site renewable energy: solar collectors for heating domestic water, and photovoltaic panels for generating electricity.
- The introduction of solar equipment requires changes in the building's energy policy and equipment maintenance.
- The installation of energy sub-meters should improve the energy management in the building.
- The architectural changes improve the integration of the building with its environment.
- The retrofitting (principle: three rooms of $10m^2$ transformed into two studios of $15m^2$) generally improves the students' living and working conditions.

- A bulletin board in the residence hall is used to highlight renewable energy use by showing current solar energy production and external climatic parameters. An newsletter on eco-living, describing the green building approach and implementation, is also distributed to students.

10 Info

10.1 References

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