CASE STUDY 1-03: IZUBA ENERGIES BUILDING | FRANCE

GEOGRAPHICAL AND CLIMATE INFORMATION

Location	34690 Fabrègues, France
Latitude; Longitude	43.56050216309316, 3.7915132981980086
Climate zone (Köppen–Geiger classification)	Csa: Warm temperate climate with dry and hot summer

BUILDING INFORMATION

Building Type	Offices
Project Type	New construction
Completion Date	2015
Number of buildings	1
Number of storeys	2
Total Floor Area (m²)	-
Net Floor Area (m²)	424
Thermally conditioned space area (m²)	424
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	0
Total cost (€)	934 000
Cost /m² (€/m²)	2 061,8
Performance Standards or Certification	None
Awards	None

STAKEHOLDERS

Building Owner/ Representative	Izuba Energies / Eduardo Serodio - eduardo.serodio@izuba.fr - 0467186221
Architect	RIGASSI et Associés Architectes / Vincent RIGASSI vincent.rigassi@ra2.fr - 0476471172 -
Construction manager	RIGASSI et Associés Architectes
Environmental consultancy	Izuba Energies

Structural Engineer, Civil Engineer	Gaujard Technologie Scop (Wood structures) Soraetec (Concrete)
Energy Engineer	IZUBA énergies
Fluid Systems Engineer	Agence Des Fluides Cognin
Product Manufacturer	Jolie Terre entreprise (Earth plasters) Sud Est Charpente (Timber frame insulation straw)
Certification company	-

PROJECT DESCRIPTION [1] [2]

Figure 26 : Exterior view of the Izuba building

Izuba Energies Building is an office building located in France, more precisely near Montpellier, on the Fabrègues Ecoparc. The building construction is based on a bioclimatic architectural conception, using local bio-based materials so as to reduce environmental impacts. The building was built in order to adapt to the local Mediterranean climate, ensuring a comfortable working environment in summer and in winter, in terms of thermal and visual comfort. This building reflects what IZUBA Energies has supported since its creation in 2001, i.e a "negawatt" energy approach with its 3 components (sufficiency, efficiency and renewable energies). This includes: hygrothermal comfort, low impact components, user behaviour, waste management, indoor air quality, and so on.

Figure 27: Floor plan of the first floor

Figure 28: Floor plan of the second floor

SITE INTEGRATION

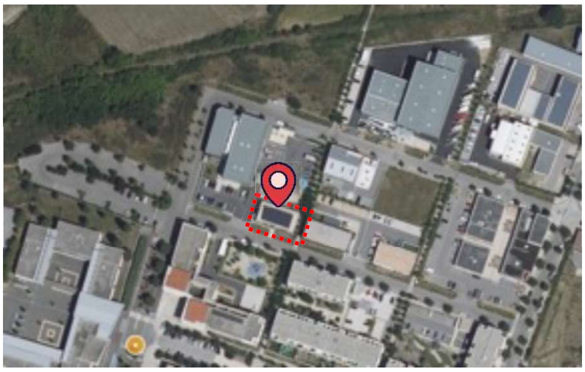


Figure 29 : Aerial view of the building in its surrounding environment

The building is located in the Eco-Parc Fabrègues, between a residential area and a rural area. A direct connection of the area from the centre of Montpellier will be possible through a future extension of the tramway line.

CLIMATE ANALYSIS

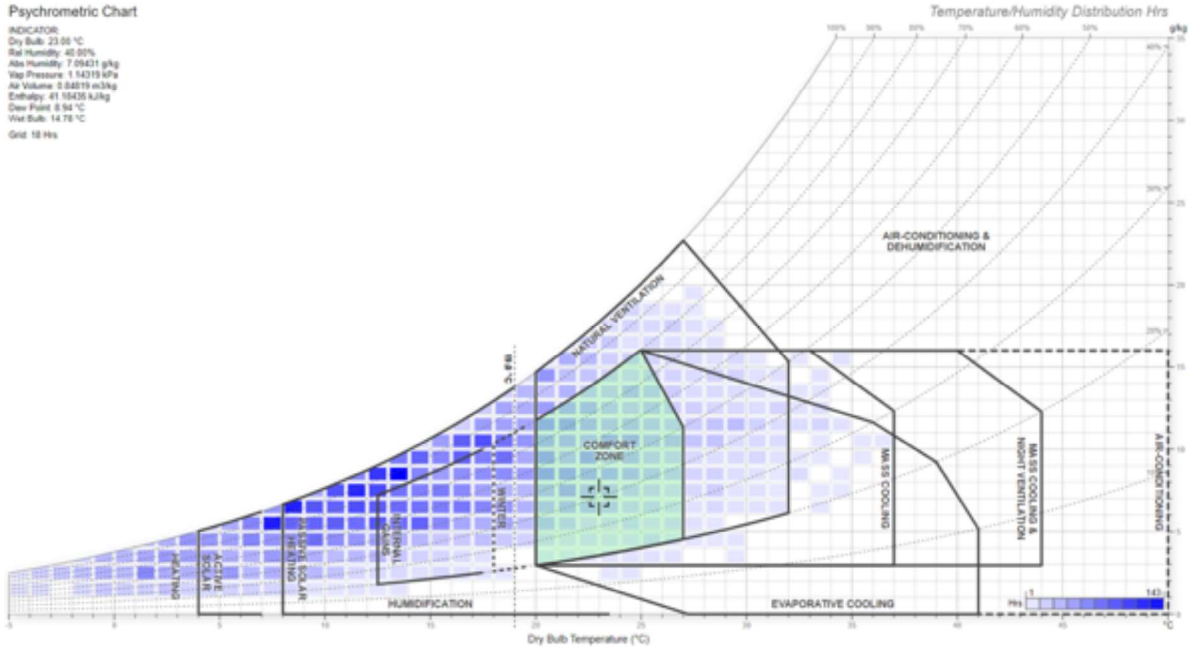


Figure 30: Givoni Bioclimatic chart for the climate of Montpellier using Andrew Marsh online tool. Climate data are extracted from https://energyplus.net/weather-region/europe_wmo_region_6/FRA%20%20 [3].

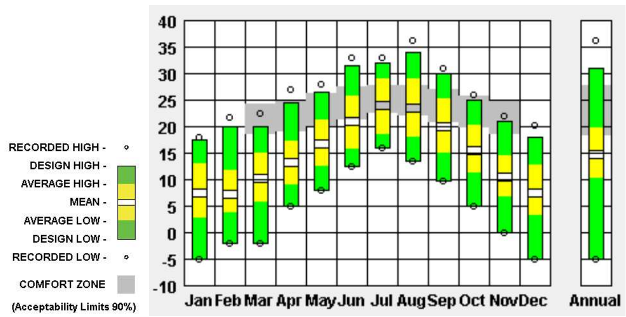


Figure 31: Temperature range by month for Montpellier - Adaptative Comfort model [4]

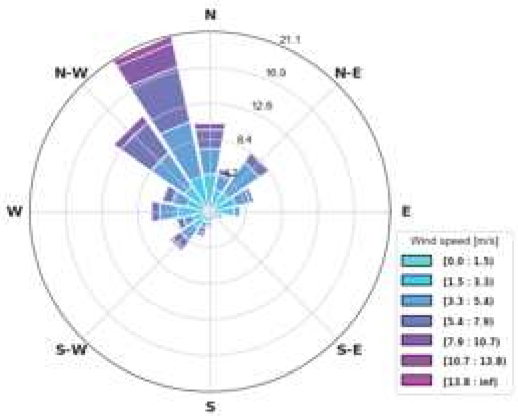


Figure 32: Annual wind rose for Montpellier ((Beaufort wind scale). [4]

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **1 413** Wh/m² (Dec) Max: **6 746** Wh/m² (Jul) Mean: **4 004,17** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **1 769** CDD 10°C: **2 181**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017 for 80% of acceptability	HDD: **1 884** CDD: **20**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **1 918** CDD 26º: **65**

KEY BIOCLIMATIC DESIGN PRINCIPLES [1] [2]	
Passive cooling strategy	**Natural ventilation** (see *Figure 33*) **Thermal inertia** (wood frame+ interior partitions of earth-straw and mud brick)
Passive heating strategy	High level of insulation of the walls and the roof Simple shape and good compactness of the building, limiting heat losses on surfaces. The main façade is south oriented so as to optimize solar gain in offices in the winter period.
Solar protection	Built-in fixed protection: - The building is completely surrounded by open-cut wood siding. - Motor drive external venetian blinds (see Figure 35). The building is equipped with fixed and mobile solar protection blocking direct sunlight while allowing solar gain in winter.
Building orientation	Main orientation south to take advantage of solar gain.
Insulation	The exterior walls and the roof are composed of timber frame insulated with straw bales which provides a very high level of insulation. Interior walls also provide high level of thermal and acoustic insulation with different strategies such as wood wool, mud bricks or cob. The high insulation levels, combined with perfect air tightness and strong solar inputs, reduce heating requirements.
Vegetation	Mediterranean plants, adapted to conserve water and survive summer drought, have been planted around the building. The different species have been chosen according to the solar exposition, i.e., linden trees for the shading of the parking areas, jasmine for the North and South façades. Also, a small common herb garden is provided.
Natural daylighting	The large openings on the main façades, as well as the fixed and mobile solar protection as been designed so as to allow natural daylighting in the building (see Figure 36).
Use of local and embedded materials	The earth used in the construction was extracted from a quarry near Uzes, composed of sand, clay and plant fibres (mostly straw).
Water saving and heat recovery on hot water drain	Flow controller fitted onto water tap in the bathroom to reduce water consumption. Hand wash basin with knee operation and with automatic shut-off.
Waste management	Sorting of recyclable waste and compost bin for kitchen waste.
Others features	**Eco-design material:** To limit the environmental impact of the manufacture of building materials and processing end of life, the design has largely favoured bio-sourced materials, minimally processed and recyclable: - Wooden frame insulated straw bale - earth plasters, clay walls and straw wall in mud brick - wood for exterior and interior joinery and furniture - anhydrite screed sanded and oiled finished floor The building includes a 19-seat parking lot, with shading structures designed to limit the use of air conditioning. There are also electric vehicle charging stations and local bicycle coverage.

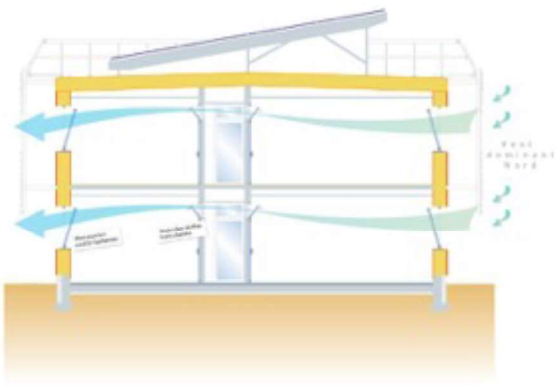


Figure 33: Natural ventilation principle

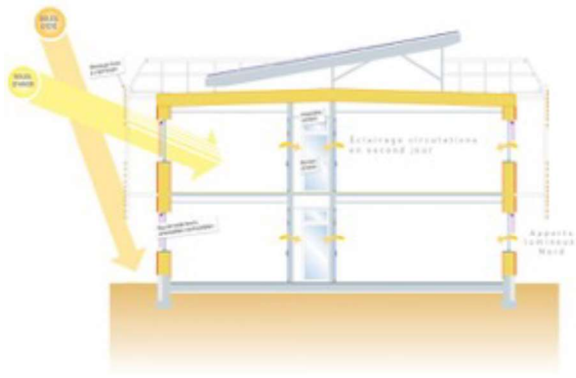


Figure 34 : Shading and natural daylighting principle

Figure 35: Motor drive external venetian blind. Type: Grinotex from Griesser.

Figure 36: Tilt and turn windows

INFRASTRUCTURES and REGULATIONS to enable SUFFICIENCY ACTION	
Dressing code	Informal dressing, adapted to the season, is welcome and promoted (e.g. short trousers and short leaves in hot periods): **Yes**
Protected bike parking and showers	Yes. **3 bike racks** and **2 showers** for 16 employees Ratio with number of users: **0.125**
Ceiling fans	In every room, even those conditioned: **Yes** Only in the offices, the kitchen and the meeting room. No ceiling fans in the large training room.
Lighting system fractioned to allow using light only in zones occupied and where daylighting insufficient	In every room, even those conditioned: **Yes**
Space and facilities for line drying clothes (especially important in residences, hotels, sport facilities…)	In every room, even those conditioned: **No**
Book of instruction for correct use of the passive features (windows, solar protections, water savings) and active (lighting…) in order to promote sufficiency and efficiency actions	Available through leaflets and posters at relevant places, online, etc.: **No** The users work in the energy efficiency area and are aware of how to correctly use the building but this point could be improved.

BUILDING FABRIC AND MATERIALS [1] [2]	
Roof	The roof is structured as illustrated in Figure 41 (from outside to inside): ▪ thermoplastic polyolefin membrane ▪ OSB wood panel (1.8 cm) ▪ Straw bale (34cm) ▪ Vapour barrier ▪ Wooden batten (3 cm) ▪ Acoustical false ceiling in wood fiber
	U-value= 0.15 [W / m²K] Overall R-value: 6.67 [m^{2}K/W]
Windows	Type of materials: Wooden-framed double-glazed windows 4/16/4 with argon, low-E
	Window-to-wall ratio (WWR): -
	U-value: 1.5 [W / m²K]
	Visual transmittance: -
Walls	The **Exterior Walls** are structured as illustrated in Figure 40 (from outside to inside): ▪ Raw earth outside coating ▪ Wooden box with thick straw bales (0.37m) ▪ OSB panel (0.018 m) ▪ Raw earth coating
	U-value= 0.17 [W / m²K] Overall R-value: 5.88 [m^{2}K/W]
	The different types of **Interior Walls** are structured as illustrated in Figure 42 (from outside to inside): **<u>Type 1 (thickness= 0.198m):</u>** ▪ Gypsum board (0.013m) ▪ Timber frame 45/120mm with 0.12m of wood wool ▪ OSB panel (0.012m) ▪ Gypsum board (0.013m) **<u>Type 2 (thickness= 0.172m):</u>** ▪ Raw earth coating ▪ Mud bricks ▪ Timber frame 45/120mm and OSB panel (0.012m) ▪ Raw earth coating **<u>Type 3 (thickness= 0.100m):</u>** These interior walls are designed using the old-fashioned cob method: a self-supporting lath made of pine from “Cévennes” supports the earth-straw mixture. The total thickness of the wall is 10 cm. To ensure acoustic insulation, it is composed of two 3 cm layers of cob separated by 2 cm of wood wool insulation and 2cm of raw earth coating.

Figure 37: Wood timber structure

Figure 38: Bunches of straw and wood fiber insulation in exterior walls

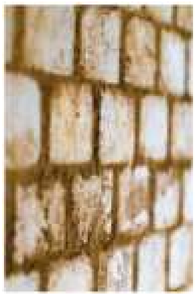


Figure 39: Mudbric wall

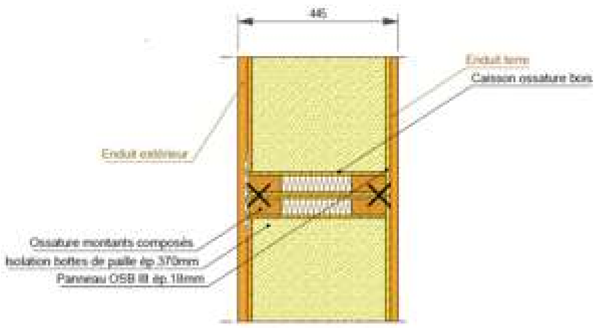


Figure 40: Exterior wall section

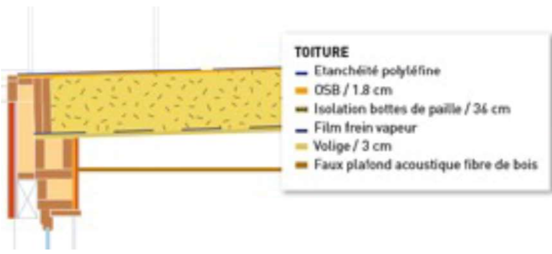
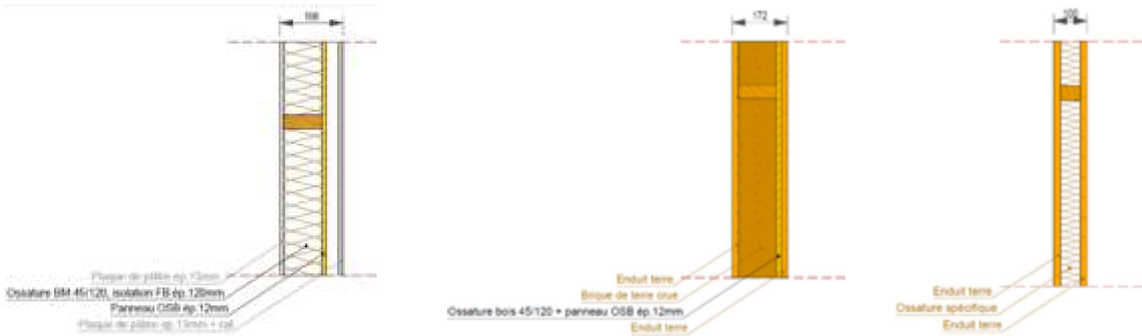


Figure 41 : Roof section details



Type 1 Type 2 Type 3

Figure 42: Details of the different types of interior walls that composed the building.

ENERGY EFFICIENT BUILDING SYSTEMS [1] [2]	
Low-energy cooling systems	Comfort ventilation & Nocturnal convective cooling Geothermal heat pump Floor cooling Fan coil
Low-energy heating systems	Geothermal heat pump; Low temperature floor heating Fan coil
Ceiling fans	1 in each office and 1 in the meeting room. Ceiling fans with 3 blades and with integrated LED lighting and remote control from Shakespear brand.

Mechanical ventilation / air renewal	Dual flow ventilation system: Swegon Gold RX TOP Maximum flow= 1200 m^3/h Efficiency of the wheel exchanger= 81% Air tightness of the duct system= Class C
Domestic Hot Water	Solar Thermal ECS electro-solar water heater of 200 litres 1 solar thermal collector of 2 m²
Artificial lighting	**Offices, training rooms and meeting rooms:** T5 light bulbs- 6 to 14 W / m²c- equipped with presence sensors and daylight linked dimming systems. **Circulation areas and sanitary facility:** LED – 3 to 8 W/m² - equipped with presence sensors **Storage, server room:** compact fluorescent lamps - 13 W/m²
Control and energy management	Building Management System: Trend 963 Supervisor Measurement of the energy consumption and the energy production with a 10 minutes timestep. Visualization and control of the heating, cooling and ventilation systems. Different energy savings features have been implemented such as presence sensors and daylight linked dimming systems, as well as multi-socket adaptors with a power switch.

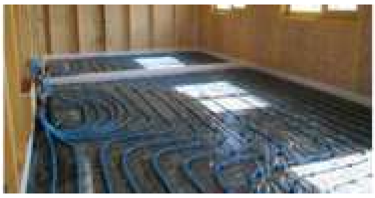


Figure 43: The building is equipped with an under-floor heating/cooling system powered by a ground source heat pump

Figure 44 : Double flow mechanical ventilation system

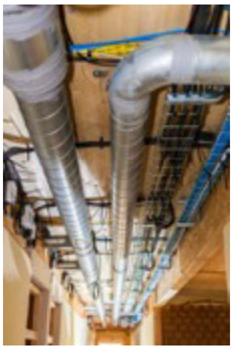


Figure 45 : Air distribution system of the building

Figure 46 : Lighting of the training room with presence sensors and daylight linked dimming systems

Figure 47 : Multi-socket adaptors with a power switch

RENEWABLE ENERGY [1] [2]	
PV	88 PV modules from the Sunpower brand - E20-327-COM **Total Power=** 28.8 kWp Solar Cell Efficiency= 20.4%

ABC21 is funded by the EU's H2020 programme

Solar thermal	ECS electro-solar water heater of 200 litres 1 solar thermal collector of 2 m²
Wind	None
Geothermal	Heat Pump on geothermal probes Heat pump Weishaupt WWP S 10 IBER - Heat: 9.5 kW, COP 4.2 - Cold: 14.6 kW, EER 9.1
Biomass	None

Figure 48: View of the PV panels installed on the rooftop of the building

Figure 49: Solar inverter and sensors of the PV system

BUILDING ANALYSIS AND KEY PERFORMANCE INDICATORS

Thermal comfort indicators

1. Percentage of time outside an operative temperature range (Adaptive)
2. Percentage of time outside an operative temperature range (Fanger)
3. Degree-hours (Adaptive)
4. Degree-hours (Fanger)
5. Percentage of time inside the Givoni comfort zone of 1m/s: **100%**
6. Percentage of time inside the Givoni comfort zone of 0m/s: **96%**

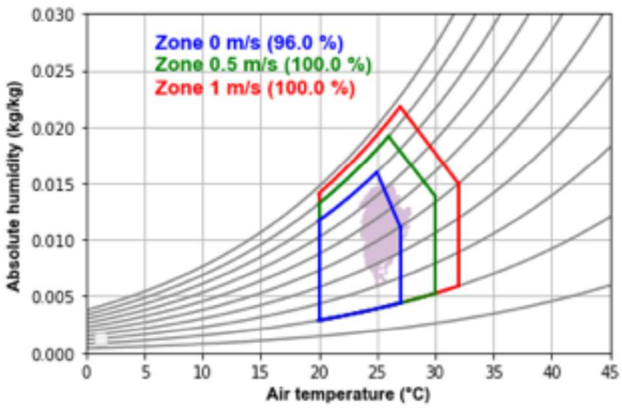


Figure 50 : Givoni comfort zones on the psychometric chart obtained for the 5 monitored rooms of the IZUBA building during occupied hours for the hot period (June 23th to September 6th, 2022). The heat pump was switched on.

7. Number of hours within a certain temperature range:

Summer period (Jun. 23th to Sept. 6th, 2022) Occupation time: 9:00am to 6:00pm		
Range	Nb of Hours	Frequency
Ta≤24	21	1%
24<Ta≤26	2061	76%
26<Ta≤28	618	23%
Ta>28	0	0%

Energy performance indicators	1. Energy needs for heating= **4.1** [kWh/m²/year]
	2. Energy needs for cooling= **2.1** [kWh/m²/year] The part for ventilation is equal to **11.8** [kWh/m²/year]
	3. Energy use for lighting= **7.1** [kWh/m²/year]
	4. Energy needs for Sanitary Hot water= **1.3** [kWh/m²/year]
	5. Total primary energy use = **73,5** [kWh/m²/year] (total Primary Energy Factor (PEF) equal to **2.58** for electrical energy from the grid)
	6. Renewable primary energy generated on-site = **117.1** [kWh/m²/year] in 2017 PV: 82.9% / Geothermal: 16.9% / Solar thermal: 0.2%
	7. Renewable primary energy generated on-site and self-consumed= **20** [kWh/m²/year] in 2017 (Geothermal & Solar thermal)
	8. Renewable primary energy exported to the grid= **97.1** [kWh/m²/year] in 2017 (PV)
	9. Ratio of renewable primary energy over the total primary energy use (with and without compensation) = **27% (generated on-site and self-consumed)** **132% (exported to the grid)**
	10. Delivered energy (measured in 2017) = **28,5** [kWh/m²/year]
Acoustic comfort indicators	1. Airborne sound insulation
	2. Equivalent continuous sound Level
	3. HVAC noise level
	4. Reverberation time
	5. Masking/barriers
Visual comfort indicators	1. Light level (illuminance)
	2. Useful Daylight Illuminance (UDI)
	3. Glare control
	4. Quality view
	5. Zoning control
Indoor Air Quality indicators	1. Organic compound
	2. VOCs
	3. Inorganic gases
	4. Particulates (filtration)
	5. Minimum outdoor air provision
	6. Moisture (humidity, leaks)
	7. Hazard material

ABC21 is funded by the EU's H2020 programme

Users' feedback	The occupant satisfaction is generally very positive. 80% of the respondents consider that their environment is thermally comfortable, both in summer and winter. The users also find that the building is comfortable in terms of acoustic and natural lighting. They also appreciate the smell of wood. The post occupancy evaluation highlighted that thermal comfort is sometimes difficult to adjust due to the individual sensitivity of the occupants.

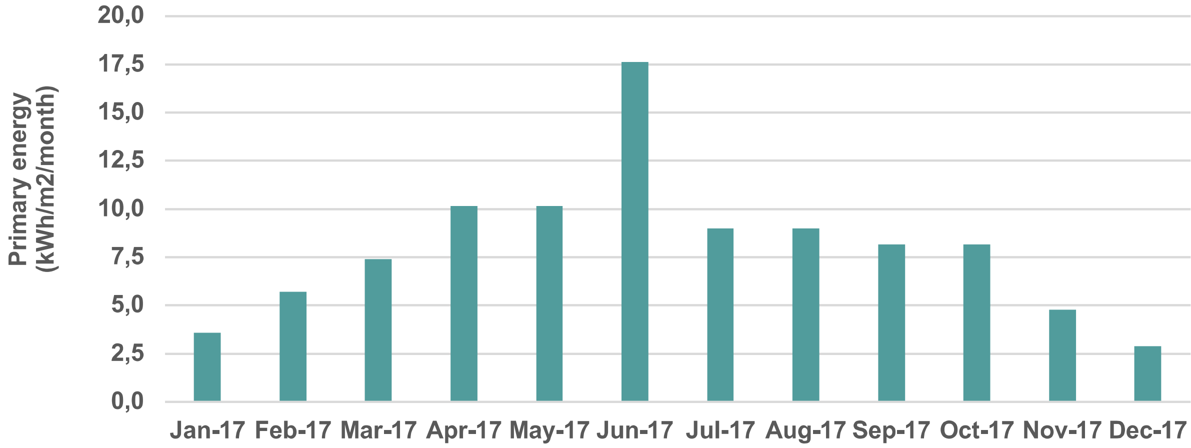


Figure 51: Monthly primary energy generated on-site from PV for the year 2017.

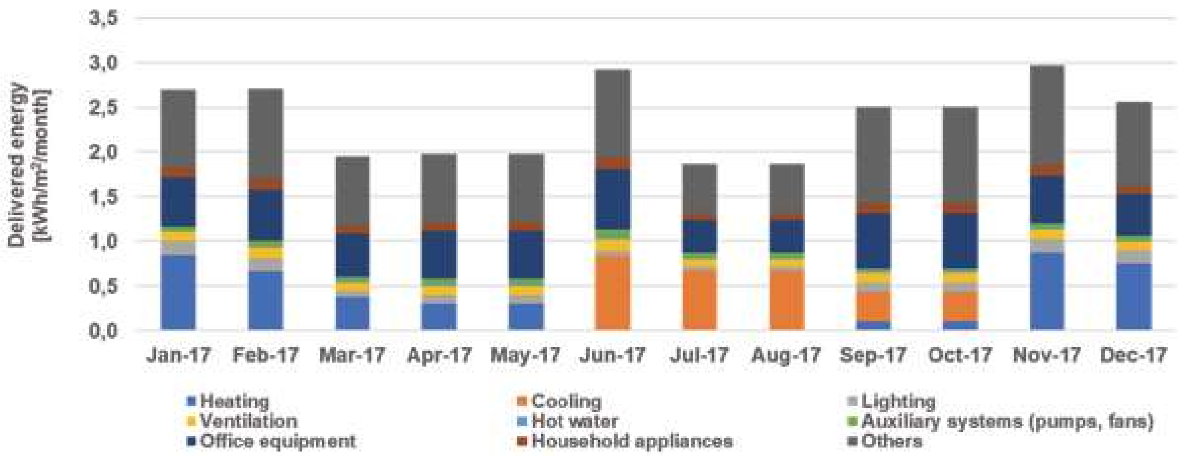


Figure 52: Monthly delivered energy by end-uses for the year 2017.

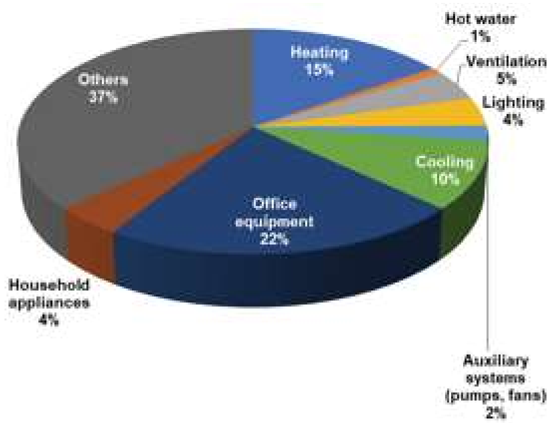


Figure 53: Distribution of all end-uses of the building over the year 2017.

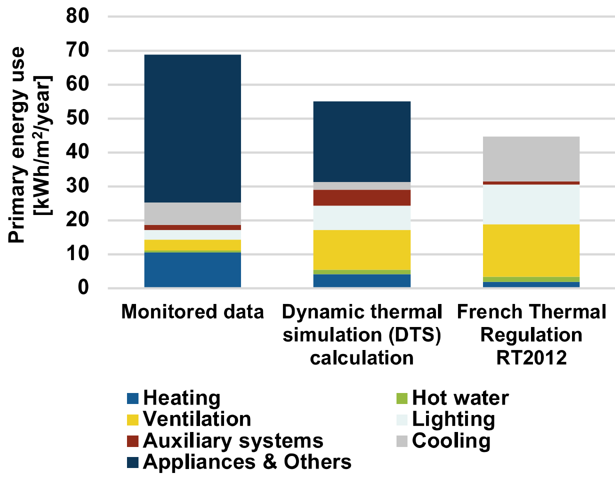


Figure 54: Primary energy use of the building by end-uses for the year 2017. Measured data are different from the simulated and calculated ones. The energy use for non-regulatory uses (Appliances & Others) is almost twice as high as the estimated one. The primary energy use of the building for all regulatory uses (All uses except appliances & others) is lower than the results predicted by the simulation or the French Regulation RT2012 calculations.

LESSONS LEARNED AND RECOMMENDATIONS

Lessons learned

An analysis of the monitored data obtained for energy and thermal comfort was done after the first year of operation. The first finding is that the measured delivered energy part for heating is higher than the calculated one. This difference can be explained by a higher setpoint temperature (21°C) than the one considered in the calculation (19°C) as well as by a non-optimal operation of the installation during this first year.

The measured ventilation and lighting delivered energy are lower than those calculated. These results show that the ventilation system is very efficient and that the air handling system has been correctly sized. The good natural lighting of the building combined with efficient and well-regulated equipment explains the good result on lighting. The delivered energy for non-regulatory uses such as appliances or office's equipment (and others than heating, cooling, ventilation, lighting, hot water) is almost twice as high as the estimated one obtained from simulation. The lack of additional sub-meters makes it difficult to carry out a detailed analysis that would provide a better understanding of the distribution of this energy consumption and the precise origin of this underestimation. Overall, the delivered energy of the building for all regulatory uses is lower than the results predicted by the simulation or the French Regulation RT2012 calculations.

With a higher photovoltaic production than the one predicted by the calculation as well as a consumption balance that is globally lower, the positive energy balance is confirmed by the measurements.

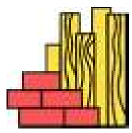
After an initial period of adjustments for the first winter, the set point for optimal comfort for all was found: 21°C. This temperature, higher than the 19°C proposed by the heating engineers, proved to be more suitable for work in a sitting position.

For summer comfort, practice has contradicted some of the initial assumptions. Indeed, (7. In summer, the office departure times are incompatible with the opening of the windows. The outside temperature is still 5 to 10°C higher than the inside temperature. Unfortunately, the occupants have left by the time it gets cool at night. In addition, the geocooling mode of the heat pump is not used since the return temperature of the probes is just at the limit of the maximum temperature required by the heat pump to allow this operating mode (17°C). The possibilities of setting the

	parameters of the heat pump are limited. A test borehole would have made it possible to anticipate this behaviour of the ground, but it was not economically feasible on such a small project. Initially designed to ventilate without heat loss in winter, the double flow ventilation was also a very good ally in the fight against overheating. The excellent exchange efficiency allowed the outside air to be cooled from 35°C to 28°C before insufflation and after exchange with the extract air at 26-27°C.
Recommendations	The introduction of a rainwater collection system would lead to an efficient and sustainable use of water for domestic purpose. The measurement of the delivered energy of a building is recommended. The measured consumptions can be compared to the simulation and regulatory calculations, which allows to appreciate the relevance of the retained calculation hypotheses, as well as the strengths and weaknesses of the real building. Besides, it allows to identify and correct, if necessary, any drift or anomalies in the delivered energy consumption. Monitored data also improve knowledge of the behaviour of the building, its equipment and its occupants. Feedback on high performance buildings is essential to encourage the reproducibility of this type of design.

BUILDING STRENGTHS AND WEAKNESSES

Strengths

			
Passive Design	**Energy Efficiency**	**Renewable Energy**	**Local Materials**

Weaknesses

The site where the building is located is bare of vegetation and shaded areas which increases the heat caused by radiation especially in the summer season.

REFERENCES

[1] https://batiment.izuba.fr/

[2] https://www.construction21.org/case-studies/fr/izuba-energies-building.html

[3] PD: Psychrometric Chart n.d. https://drajmarsh.bitbucket.io/psychro-chart2d.html(accessed May 7, 2021).

[4] Milne (UCLA) M. Climate Consultant 6.0. n.d. http://www.energy-design-tools.aud.ucla.edu/climate-consultant/request-climate-consultant.php.

ABC21 is funded by the EU's H2020 programme