Elithis Tower in Dijon, France

Elithis Tower, located in Dijon, France, provides strong evidence that net zero energy office buildings are achievable in near future. The building, which was designed by Arte Charpentier Architects, also produces six times fewer greenhouse gas emissions than traditional office structures.

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Elithis Tower: development, planning and actors	
Financing:	ADEME, Conseil Regional de Bourgogne
Net construction costs:	EUR 7 millions, 1 400 € per m^2 (equals the cost for a standard building in France)
Project Team:	Elithis Ingénierie, ARTE Charpentier.

The Elithis Tower is an experimental and demonstration building. Experimental because many R&D are being done in order to improve energy performance. Demonstration because the principal objective was to erect a nnZEB building with architecture fitted to an urban environment.

An environmental protocol was signed by all the permanent co-owners of the Elithis Tower in order to ensure to lowest impact between user's behavior and the building. The energy production of the building in kW per hour and the greenhouse gas compensation is permanently projected to the advertising board on the public road.

Thermal comfort, indoor air quality and energy use are being constantly monitored with 1600 data points installed all over the building. In addition, occupant surveys are done for the users. Users are asked to fill in a questionnaire at the same time as the environmental variables are being recorded through the BEM system. The study began in June 2010 and the first results report a general comfort level of 72% (winter season) including thermal and visual comfort and indoor air quality.

Building description

The main aim of the building is to use passive means and natural resources such as sun and wood to achieve thermal and visual comfort in the building.

In order to improve the best performances in natural lighting the Elithis Tower was designed in an open plan distribution. Unfortunately, this configuration wasn't adopted all over the building (medical services). Most part of the offices are in an open plan distribution. But for the other offices a glass wall and insulated wall division was installed. The open plan distribution could ensures,the best internal air distribution, this solution gives the possibility to perform the air contact with the walls and to reduce the energy requirements for the cooling and heating

Table 1. Climate data.

Design outdoor temperature for heating	-11°C
Design outdoor temperature and RH for cooling	32°C / 38%
Heating degree days (base temperature)	2 650 Degree days (base 18°C)

Table 2. Summary of key building parameters.

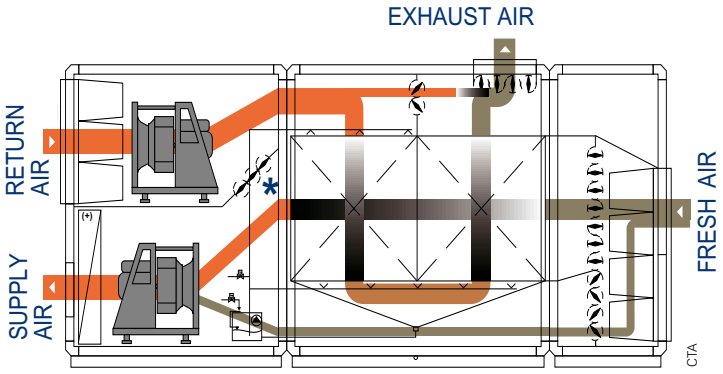
Building type	Office
Net floor area	4 500 m^2
Gross floor area	5 000 m^2
Gross volume	16 7500 m^3
Mean occupant density	15 m^2/person (overall average)
Occupied hours	2 450 h

Table 3. Building envelope data.

Window U-value	1.1 W/(m^2 K)
Window g-value	0.4
Exterior wall U-value	0.32 W/(m^2 K)
Base floor U-value	0.39 W/(m^2 K)
Roof U-value	0.22 W/(m^2 K)
Structural frame	Heavy weight (concrete & steel)

The Elithis tower is composed of 9 levels and 1 technical level (HVAC system). The height is 33.5 meters. 4 levels are occupied by Elithis engineering, and the others by the Ademe (Departmental Agency of Energy Management), radiological services, a restaurant and other civil engineer companies.

The building has a central core made of concrete and the facades are made of wood and recyclable insulation (cellulose wadding). The surface fenestration is about 75% of the facades. The windows are double-glazed with an argon air space. The thermal mass of the building can be considered as medium because the central core only is the exposed concrete.



Ventilation operation with controlled heat recovery during typical outdoor temperatures in the heating season.

A photo of the façade intake.

DESIGN CONCEPTS

1. Compact building shape

Elithis Tower has very compact rounded shape effectively reducing building envelope area. The architecture was carefully studied in the design. The building envelope area of the Elithis Tower is about 10% less than in a conventional tower. Reducing the surface has a positive effect regarding heat losses and solar gains. Similarly the exposure to the wind is reduced so the infiltration can be better controlled. In the same time, the air distribution in the mixed ventilation mode, can be more homogeneous thanks to the rounded shape.

2. The passive solar shading.

In order to combine natural light, avoid glare and reduce solar gains, a special solar shading shield was designed by the Elithis engineers and architects. This passive system gives to the building the necessary natural light and the solar glare protection in summer and mid-season, while excess heat is utilized to heat the building in winter. The system was carefully studied in order to retrieve the necessary solar energy during the winter season and to protect the building during the hot periods.

3. Ventilation strategy

The building is ventilated by mechanical supply and exhaust system with heat recovery controlled by the BEM system in order to comply with the French ventilations standards codes (25 m^3/h per person in offices). The ventilation system is operated in three modes depending on the season.

For typical heating season operation (outdoor temperature higher than 0°C), operation with controlled heat recovery is used to heat up supply air with heat recovered from extract air. Heat recovery is controlled/bypassed so that supply air temperature is between of 16 to 18°C. The full heat recovery operation is used for extremely cold or warm outside conditions (less than of 0°C in winter or higher than 26°C in summer).

In the mid-seasons (spring and fall) and summer operation, the triple flow mixed mode system which is an Elithis innovation, is used. It gives the possibility for ventilative cooling with fresh air intakes and central atrium exhaust ventilation in order to cool the building. 32 air valves in facades per level are used to have additional intake air. In this mode, air handling units are operated together with intake air from facades and atrium low pressure exhaust fans.

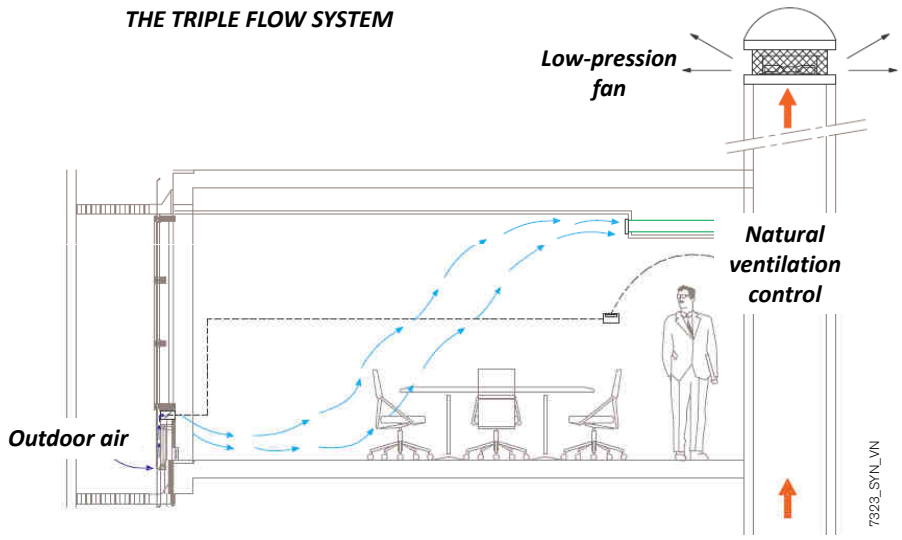
The third operation mode is the free cooling. Air handling units are stopped and atrium exhaust used in order to ventilate the building in night summer time. In this mode, the building can be ventilated with low pressure central atrium exhaust ventilation. The 32 air valves are opened in order to ventilate the building with two or three times higher flow rate than the design air flow rate.

4. Lighting system

In natural lighting, increased rate of the glass surface reduces energy use needed for artificial lighting. The passive

solar shading of the Elithis Tower protects the users from the direct solar radiation and provides an excellent natural lighting for the office tasks avoiding the glare problems.

Light fittings in the ceiling provide the average lighting (300 lux-French building standard codes) over the entire office space. For the low lighting outdoors levels, at night or very cloudy days, motion sensors were coupled with lighting sensors. This solution provides the perfect compromise between energy use and lighting requirements. Installed lighting power is only about 2 W/m² of electrical energy. For tasks requiring a higher level of illumination, task lighting with "Nomadic lamps" is used. All this is controlled by the BEM system.



In the mixed mode operation, façade intakes and low pressure atrium exhaust fans are used. This is used for the night time ventilative cooling, and in the midseason, when the ventilation by air handling units is forced for cooling purposes.

5. Heating and Cooling system

The major part of the heating needs is covered by solar and internal heat gains. For the rest of heating needs, one very low-power wood boiler provides the heat in order to ensure the thermal comfort. A second one wood boiler is used only for back-up. This system is used to maintain the 21°C room temperature all over the building.

The triple flow ventilation system covers the most important part of the cooling needs. When room temperatures reach 26°C, a cooling system consisting of adiabatic unit and heat pump are started to operate. This heat pump system with a high EER of (EER=11) provides air conditioning of the building. It's in a two stages. The first one is an adiabatic process; the heat is evacuated by the water evaporation. The second stage of the heat pump is only needed to operate for extremely outside weather conditions (outdoor temperature higher than 30°C).

6. Heating and cooling distribution

Chilled beams of a rectangular cassette size are use as room conditioning units both for cooling and heating and ventilation supply air. Chilled beams are induction devices circulating room air through the coil. Circulating air flow is induced by supply air nozzle jets integrated into chilled beams. 32 chilled beams are installed per level and controlled by the BEM system.

7. Water management

Water management is written in the policies of the Elithis Tower. A rain water recovery system is used to supply the toilets of the building. All fixtures and fittings such as sink faucets and toilets aims to very low water consumption in order to preserve the water resource.

Chilled beams cassettes and lighting installation.

Energy performance

The energy concept of Elithis Tower is to balance the primary energy of all energy uses with the PV electricity generation and the user behavior. A building by itself can't be nnZEB without a good operation and maintenance and users behavior. The Elithis Tower has a very low ratio of installed PV area to the floor area. The very low energy use of the building is balanced by only 500 m² of Photovoltaic's roof panels. The PV panels are

Table 4. Simulated and measured energy performance of the building after the first year of operation. All specific values are per gross floor area. For the net floor area values, the values in the table are to be multiplied with factor of 1.1.

	Design phase			Measured 2009
	Net delivered energy use kWh/(m² a)	**Primary energy factor** -	**Primary energy use** kWh/(m² a)	**Primary energy use** kWh/(m² a)
Space, water and ventilation heating, wood boiler	3.3	0,6	2.0	6.3
Cooling, electricity to heat pumps	4.1	2,58	10.6	6.2
Fans (HVAC)	5.1	2,58	13.1	14.1
Pumps (HVAC)	0.4	2,58	1.1	2.6
Lighting	4.1	2,58	10.5	9.5
Elevators	1.4	2,58	3.6	3.6
Appliances (plug loads)	9.4	2,58	24.2	54.6
PV power generation	-16.0	2,58	-41.3	-40.2
Total	**12**		**24**	**57**

installed with a horizontal inclination in order to maximize the generation.

An energy management system with 1 600 data points allows the control and the management of all technical systems (HVAC, lighting, elevators). Many energy meters are installed in all the building, to make it possible to know energy use on the system and component level. Simulated and measured energy performance of the building after the first year of operation is shown in **Table 4**.

The highest component in the energy balance are the appliances (plug loads), which include all user electricity, i.e. computers and other office equipment, cafeteria and also data servers. This component shows also highest deviation from the design value when all other components follow well design values. The differences between the theoretical patterns and the reality can explain this difference. As the user behavior has been the most important reason to explain the differences in the energy balance of the building, Elithis Engineering is currently analyzing the problem and there are many changes planned to be implemented in order to reduce that energy use.

Measured total primary energy use for the first year of operation year has been 63 kWh/(m² a) per net floor area, 57 kWh/(m² a) per gross floor area as calculated according to French standard, which is 33 kWh/(m² a) higher than designed, due to higher energy use of appliances. (Editor's comment: If compared to two other cases studies and calculated with primary energy factor 2.0 for electricity, the primary energy value of 63 will decrease to 50, being the lowest one of the case studies reported in this issue.)

The primary energy values reported include all energy use in the building, such as cafeteria, data servers and all other activities in the building. Even the monitored primary energy value of 57 kWh/(m² a) is higher than designed, it places the Elithis tower very close to high performance net zero energy building. The design value, not reached during the first year of operation, will remain the main objective in future operation.

Experience from the operation

After nearly two years of operation, some improvements have been made or forecasted:

- At the beginning, the electricity used to light the stairways was higher than the electricity for the elevators. The problem was in the stairways lighting control, which proved to be very important because there is no natural lighting. Today a new lighting programming is studied to solve the problem.
- The energy use predicted for the appliances was underestimated. The lesson is learnt and in future this will need more careful prediction. At the beginning the device cut-off computer power was not used as expected and an awareness protocol was implemented in order to reduce the electricity use. Today the systems seem to work and an energy reduction has been achieved.
- Occupants and visitors of the Elithis Tower are satisfied. The general feeling is very satisfactory because the environment is very attractive compared with other buildings