KERGRID: A Low-Carbon Footprint Building in Western France

Pierrick Mandrou, José Naveteur, David Penhouet, René Sauger, Edouard Cereuil

Revista Română de Inginerie Civilă, Volumul 10 (2019), Numărul 3

Paper presented at CLIMA 2019 - the REHVA HVAC World Congres

KERGRID: A Low-Carbon Footprint Building in Western France

Pierrick Mandrou[1,*], *José* Naveteur[1], *David* Penhouet[1], *René* Sauger[1], and *Edouard* Cereuil[2]

[1]EDF R&D Technologies and Research for Energy Efficiency Department, 77250 Moret sur Loing et Orvanne, France
[2]MORBIHAN ENERGIES, 27 rue du Luscanen, CS 32610, 56010 Vannes, France

Abstract. MORBIHAN ENERGIES carried out an experimental project in designing a building that produces for the electricity grid for its new head office in Vannes, Brittany. It is capable of varying its consumption electric power -- especially in times of high demand -- and can also store or reinject the renewable energy it produces. This project gave birth to the KERGRID building, featuring an area of 3,300 m², in compliance with the low carbon building and PassivHauss labels. A two-storey building made of wood and concrete, it has solar panels spread over the 850 m² of roof space and two micro wind turbines that provide electricity production for the area. EDF R&D (Research and Development) is supporting Morbihan Energies in optimising the operation of its building. In 2017, all-purpose final consumption amounted to 71 kWhfe/m² while solar production amounted to 110 MWh, 63% of which was self-used. All-direct emissions of greenhouse gases amounted to 4.3 kgeqCO_2/m².year (14 TeqCO_2/year). These figures confirm the high performance of this building.

1 Context

Brittany remains one of the most electrically weakened regions in France today because of its shape. During peak times, the peninsula, which produces less than 10% of the electricity it consumes, remains exposed to high risks of cutting.

The region is therefore committed to the Pacte Electrique Breton (Brittany Electric Agreement), which aims to control the demand for electricity, to encourage the massive deployment of renewable energies and even to strengthen the power grid.

Fig. 1. Overview (MORBIHAN ENERGIES).

MORBIHAN ENERGIES carried out an experimental project in designing a building that produces for the electricity grid for its new head office in Vannes, Brittany (Fig 1 and Fig 2).

It is capable of varying its consumption electric power -- especially in times of high demand -- and can also store or reinject the renewable energy it produces It can decrease its electric power, especially in times of high demand, but also store or reinject the renewable energy it produced. This project gave birth to the KERGRID building.

Fig. 2. South access (MORBIHAN ENERGIES).

* Corresponding author: pierrick.mandrou@edf.fr

2 Description of the building

With an area of 3,300m² and mixed wood and concrete construction, the KERGRID building meets the requirements of the PassivHauss label.

A set of 524 LDK photovoltaic modules of 240Wc each amounting to a total of 850 m² is located on the roof (i.e. 125 kwp), helped by 2 micro wind turbines. Some of the local electricity production can be stored with a Saft battery with a capacity of 56 kWh. Associated with inverters and automation, this battery is managed by a Schneider Power Management System (PMS), which can manage a partial erasure of loads over several hours or supply the building for thirty minutes in case of a blackout on the grid. Several vehicles can be recharged thanks to semi-fast (7 kVA) and fast (18 kVA DC and 20 KVA AC) terminals. These terminals are also managed by the PMS to ensure a suitable recharging. Recently, Morbihan énergies acquired a 35 MPa hydrogen recharging station by electrolysis.

The heating is provided by two CIAT water/water heat pumps producing 80 kW of thermal power each (Fig 3). Associated with an exchanger, the geothermal energy also guarantees cooling by geo-cooling. Additionally, a SWEGON air handling unit also free-cools in the summer.

Fig. 3. Technical room (MORBIHAN ENERGIES).

3 Results

3.1 A building with low energy requirements

In 2017, all-purpose final consumption amounted to 71 kWhfe/m². The heating air conditioning unit represents less than a third of the final consumption with 23 kWhfe/m² (Fig 4).

The heating air conditioning unit represents less than a third of the final consumption with 23 kWhfe/m². The remaining two thirds are for other uses including sockets (30 kWhfe/m²), lighting (6 kWhfe/m²), electric vehicles (6 kWhfe/m²), server computing and outdoor lighting.

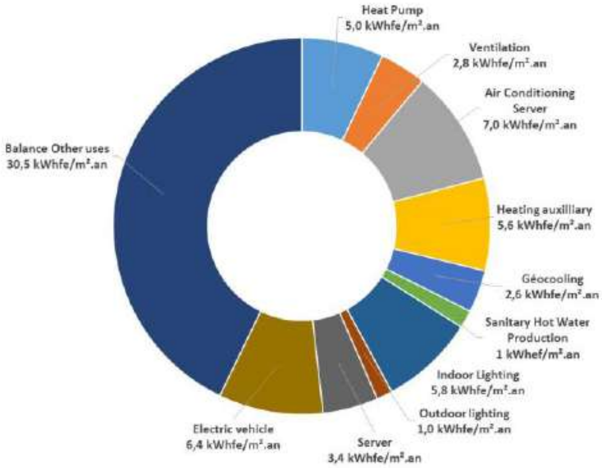

Fig. 4. Distribution of annual consumption per use over the year 2017 in kWhfe/m² (EDF R&D).

The need for heating the building is minimal, with 21 kWh/m² of useful energy; that is to say less than 9 Wh/m²/HDD (Heating Degree Days). These figures decreased by 28% over 2016 [1]. The improvement was possible thanks to sound management of the heating and an anticipation of the heating stoppages in springtime.

Moreover, the heat pump functioned well with a performance rate (COP) of 4.1. Auxiliary consumption also decreased by 16% compared to 2016 because of the shutdown of all circulators early in spring and the restart late in autumn.
Nevertheless, consumption remains significant (6 kWhfe/m²/year) and could still stand to be reduced in stopping the circulators while the heat pump is not working (Fig 5).

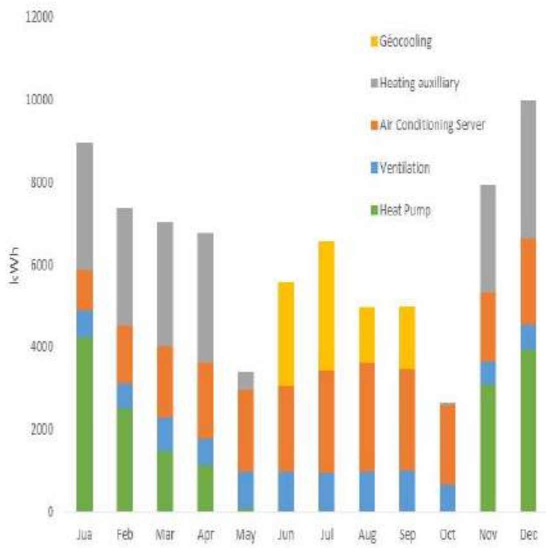

Fig. 5. Evolution of consumption in HVAC over the year 2017 (EDF R&D).

3.2 A building that fits into the National Low-Carbon Strategy

Of the five uses -- heating, ventilation, cooling, hot water production and lighting --, this building gets an 'A' grade regarding direct greenhouse gas emissions with only 2.7 kg CO_2/m^2/year (Table 1). A boiler gas solution and a chiller unit (with a performance of 95% Higher Calorific Value) would get a B grade. In this case, the geothermal solution reduces greenhouse gas emissions by more than 60% and fully adheres to the national low carbon strategy

Table 1. Distribution of annual green house emissions per use over the year 2017 in kg CO_2/m^2 (EDF R&D).

Electric uses	kg CO_2/m^2
Heat Pump and Auxiliary	1.918
Ventilation	0.113
Air Conditioning Server and geocooling	0.385
Sanitary Hot Water Production	0.043
Indoor Lighting	0.230
Total 5 uses	**2.691**

3.3 A building consuming and producing renewable energy

Concerning renewable energy, it is possible to recognise the local production of photovoltaic panels and wind turbine from the energy extracted from the ground for the operation of the heat pump.

Geothermal energy allows for three-quarters of the heating requirements of the building and all the needs of cooling in the summer thanks to geo-cooling.

As for the local production of electricity, it ensures nearly one-third of the electricity requirements necessary for the operation of the building.

Over 2017, photovoltaic production was 110 MWh, or 873 kWh/kWpeak. The volume instantly consumed by the building reached 69 MWh, i.e. 63% of the production, while the remaining 37% (41 MWh) were reinjected into the grid (Fig 6).

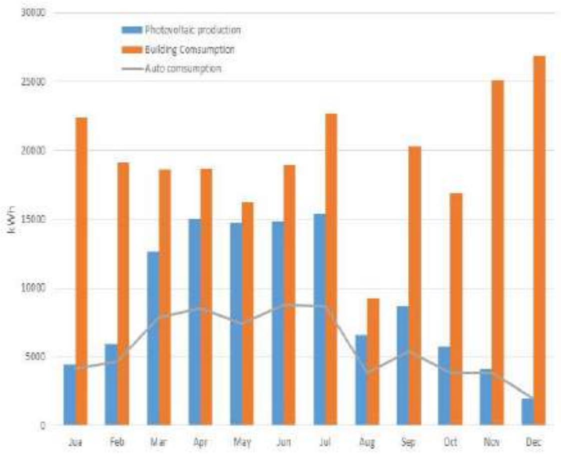

Fig. 6. Building consumption, Photovoltaic production and self consumption in 2017 (EDF R&D).

3.4 A building with low operating and investment costs

In investment, the cost of construction of this building is about €2000/m² excluding VAT. The cost of heating and ventilation systems represents 9% of the total cost, while that of the photovoltaic, wind and storage production system amounts to 15% (Table 2).

Table 2. Allocation of investment costs (estimate Front End Engineering Design – 2010).

Investment	Cost (€ HT)
Earthwork	1 069 000
Framing/Roofing/Siding	1 383 450
Woodwork	781 600
Internal arrangment	680 530
HVAC	616 250
Electricity	452 500
Photovoltaic/Wind turbin/storage	1 052 300
Green spaces	831 000

In operation: The production cost of heating MWh amounts to €41/MWh and corresponds to the cost of the electric MWh divided by the rate of the heat pump (COP). These costs include supply, subscription, and local taxes, and are given in euros excluding VAT. To compare, the production cost for a gas boiler solution (with a performance of 90% Higher Calorific Value) would be €51/MWh. Under these conditions, the cost of the energy is €9.60/m² per year and the HVAC represents only €3.12/m² per year.

4 Conclusion

This building fits into the national low Carbon Strategy thanks to its low thermal requirements in the range of 21 KWh/m² of useful energy, its local production which covers 30% of the building's electricity requirements and its low greenhouse gas heating and cooling solutions.

Recently, Morbihan Energies has embarked on an ISO 50001 certification approach aiming to optimise the consumption of its building fleet.

Based on the experimentation carried out on this building which was one of the first in auto consumption, Morbihan Energies has already begun to share its auto consumption with its neighbouring buildings, including a gymnasium and a few residential homes.

Morbihan Energies also looks at the possibilities offered by the Vehicle-to-grid (V2G), in which plug-in electric vehicles, such as battery electric vehicles (BEV) and hydrogen fuel cell electric vehicles (FCEV), communicate with the power grid to sell demand-response services by either returning electricity to the grid or by throttling their charging rate.

References

1. P. Mandrou, E. Cereuil, **Technical review CVC -** n° 896 (2017) - AICVF : Association of Engineers in Climate Ventilation and Refrigeration.