The Aerem Factory:
An Ecological Co-Designed Factory Building

The Aerem building in the South of France proves that also factories, which typically have a relative high carbon footprint, can reach positive energy standards. The building was constructed in 2018 and uses a modular steel structure as a basis which can be adapted and extended to adapt the factory for varying future uses.

The steel structure is insulated with locally harvested straw to further reduce the carbon footprint of the construction materials. The combination of steel and straw, used in an industrial context, is one of the key innovations in this project. Heating and cooling are provided by a geothermal heat pump system in combination with (high flow) night ventilation. Electricity is generated by photovoltaic panels on the roof.

The building was designed in close collaboration with its future occupants in order to understand and meet up with their functional needs. Special attention was paid to acoustic comfort, air quality and visual aspects to increase occupants' satisfaction and well-being. The Aerem factory has won the low Carbon Prize of the Green Solutions Awards both in France and internationally.

Authors: VITO / Energyville

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EXCESS

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The Positive Energy Building in its Local Context

Aerem is a cooperative company with approximately 60 employees (2018) which produces parts for the aeronautical industry since 1985. Their new factory is a positive energy building that was co-designed together with its future occupants in order to achieve an optimal design which meets all requirements (e.g. on comfort, visual, thermal, etc.). The building has a modular steel structure which is insulated with biological materials and has a total surface of approximately 3.900 m² with two floors. The factory is located in Pujaudran, a relatively small village with 1.500 inhabitants in the South of France. The planning and design phase of the building started in 2015 and the building was constructed between April and December 2018.

The Building's Special Features

The geothermal heat pumps, solar roof and thorough insulation can be considered as the key technologies that make the Aerem building a positive energy factory. In the design process, special attention was given to visual comfort for the occupants by maximizing daylight entry. In addition, a modular building structure with natural insulation materials was chosen to make the factory future proof.

The building walls are constructed out of wooden boxes filled with densely packed straw beams. This technique allows for a better air tightness of the structure. In addition, the straw offers excellent thermal and acoustic performance.

On the other hand, the concrete floors and slabs increase the thermal inertia of the building in order to absorb temperature fluctuations. The concrete is thermally activated and used for passive cooling which results in a very efficient cooling system.

Although the technical systems are relatively straightforward, the challenge was to anticipate the different scenarios that could occur during operation. Aerem produces precision parts for the aeronautical industry and these parts have to be produced and stored at a constant temperature of 21 °C. This means that the different workshops always need cooling, even in winter.

The solution was to use different air handling units for the thermal zones in the production area. Two buffer tanks (10 °C, respectively 35 °C) are integrated for optimizing heat pump operation and to improve the response time of the thermal system.

Image 1

Exterior view of the Aerem factory
[© SEUIL ARCHITECTURE]

Image 2

Cropped photograph of the reception area
[Source: © Stéphane Brugidou]

"The building has a modular steel structure which is insulated with straw-filled wooden boxes."

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Key Technologies Installed

- Geothermal heat pumps with 23x137m boreholes (a borehole thermal energy storage system is used for heating and cooling the building).
- The photovoltaic panels are installed on the roof and have a combined output power of 99.9 kWp.
- A Ventilation system with waste heat recovery captures waste heat from the workshops and recuperates heat from the exhaust airflow. During the night, the building can be ventilated at higher flow rates than during the day. As a result, the building structure can be cooled and polluted air can be extracted.
- The heavy concrete floors and slabs are thermally activated to obtain a better and more stable indoor climate.
- The air handling units inside the production area have to be able to maintain a constant indoor temperature of 21 °C. This is achieved by integrating thermal energy storages (at 10, respectively 35 °C) in order to improve the response time and controllability of the system.

Selected Performance Indicators

Breakdown of Energy Consumption

Heating:	32	kWh/m²y
Cooling:	23	kWh/m²y
Ventilation:	7	kWh/m²y
Lighting:	5	kWh/m²y
Other:	0.5	kWh/m²y

Renewable Energy Generation

Photovoltaic: 33.3 kWh/m²y

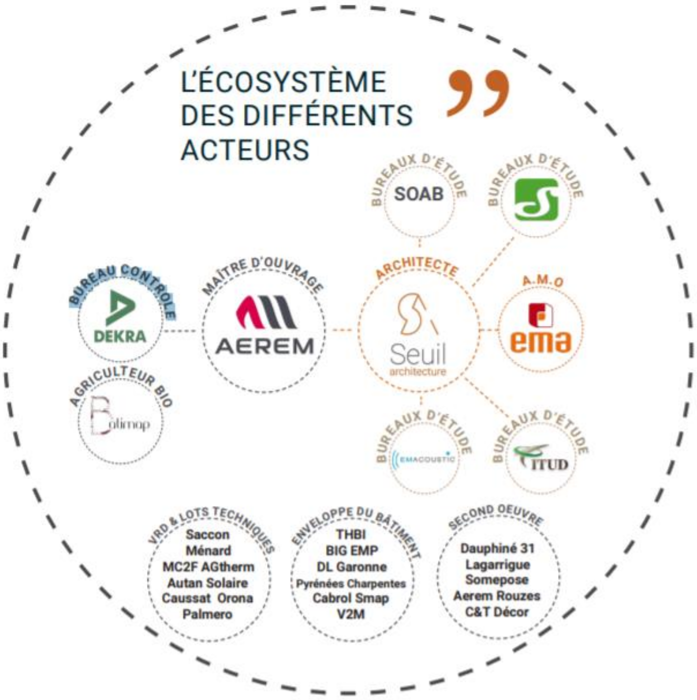
Degree of electrical energy self-supply in % based on RES [Renewable Energy Sources]:

100%

Awards:

2 times Low Carbon Prize of the Green Solutions Award (national and international) (www.construction21.org)

Non-Exhaustive List of Involved Stakeholders



Source: https://www.construction21.org/france/data/sources/users/14188/acteurs-du-projet.pdf

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Catalysts, Challenges & Results

In the construction process many challenges required adjustments, as well as knowledge and experience from different stakeholders: Firstly, the poor mechanical quality of the ground required special and more expensive foundations and there were construction related constraints regarding non-flammability of the selected insulation material (straw). Secondly, large ventilation rates are needed in the workshops to extract fumes and polluted air which could potentially result in reduced comfort throughout the building. Thirdly, the vicinity of the offices near the workshops resulted in some acoustic problems. Finally, the tight construction deadline in combination with the coordination of multiple actors proved to be a challenge.

Nevertheless, the co-design of the building and the interactions between building owner, building occupants and designers in an early phase of the project resulted in extra comfort and user satisfaction. The process was managed by installing a steering committee and by organizing participatory workshops with all employees.

The building owner and the employees reported other, more indirect beneficial outcomes of working in a positive energy building. For instance, there was a gain towards new markets and prospective customers and there was a reduction of the number of work related accidents. In addition, the health and safety conditions improved together with the dialogue between office and production.

The building costs were approximately 10% higher than for a traditional building. This additional cost can be absorbed by increasing self-consumption and obtaining subsidies for the production of renewable energy. The return on investment for the geothermal heat pump system is estimated at 7 years while for the solar panels this would be 18 years. The building was financed within commercial market conditions.

The total construction cost was 5 M€ and the investment costs for the renewable energy systems were 407 k€. The project received a total subsidy of 557 k€.

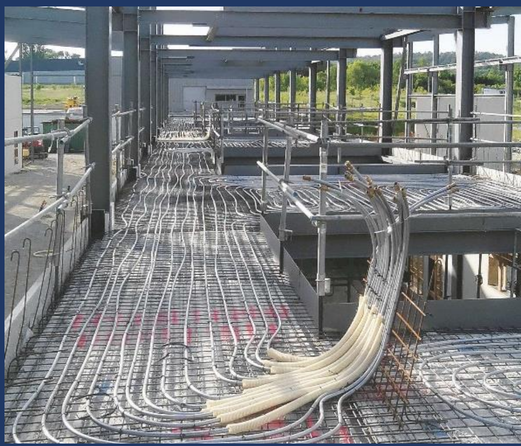

Image 3

Photograph of the floor heating system installation [Source: © SEUIL ARCHITECTURE]

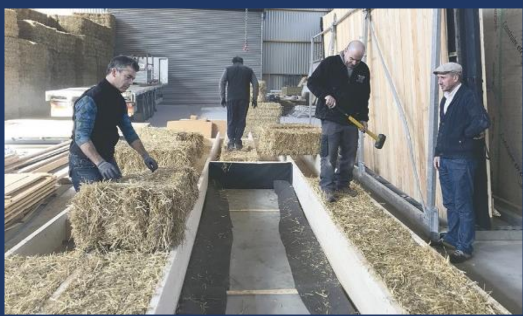

Image 4

Photograph of eco-friendly insulation being inserted [Source: © SEUIL ARCHITECTURE]

"…co-design of the building resulted in extra comfort and user satisfaction…"

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Replication Potential

France places the building sector at the heart of its strategy to meet the challenge of climate change. Buildings account for almost 45% of national energy consumption and more than 25% of greenhouse gas emissions.

In 2018, the energy transition law for green growth allowed the implementation of an ambitious environmental standard for new buildings. The French State, economic actors and associations are jointly preparing this ambition to contribute to the fight against climate change around two main directions for new construction:

- the generalization of positive energy buildings;
- the deployment of low carbon footprint buildings throughout their life cycle, from design to demolition.

In order to prepare the future environmental regulations for new construction on a shared and pragmatic basis, a national experiment is launched to test in real scale new levels of ambition and to answer questions on the feasibility of positive energy buildings. (http://www.batiment-energiecarbone.fr/)

In addition, the French ministry of Environment, Energy and Maritime Affairs has launched the "Positive Energy Territories" program which supports and provides assistance to municipalities that have committed to generate more energy than they consume. Although this approach works on a higher level, positive energy buildings are an important part of the solution.

Conclusions & Lessons Learned

The positive energy factory of Aerem in Pujaudran can be called a success story. Although the combination of office space and workshops imposed additional challenges in terms of user comfort and technical solutions, co-design proved to be essential for the realisation of such complex project.

The conditions in France seem to be favourable for the construction of Positive Energy Buildings. This can be derived from the increasing number of registered projects which can be consulted online at https://www.observatoirebbc.org/. The Bepos Effinergie label which was defined in 2013 (and later updated in 2017) supports and promotes the positive energy approach in the French building construction sector. Since the introduction of the label, some important observations were made and lessons learned. First, there is a large variety of solutions implemented throughout the Positive Energy Buildings. Priority must be given to frugality and efficiency. Also, the design team should take into account future challenges such as mobility and the construction costs should be controlled based on the design, objectives and requirements of the building. Finally, the Bepos Effinergie label is not the final step towards the generalisation of Positive Energy Buildings. It defines the next steps that are necessary for upscaling this approach, from building to district level.

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- Stéphane Brugidou for the permission to use photographs in this case study.
- Seuil architecture for allowing the authors to use their stakeholder diagram on page 3 as well as selected photographs.

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Local Context Details

Address: ZAC du Roulage, 32600 Pujaudran, France

Approximate Geographic Coordinates [Google | EPSG:4326 – WGS 84]: 43.5887659, 1.1761311

Local Government: Pujaudran (Gers)

Population: 1,461 (2015) Total Area Administered: 17.4 km² Municipal Budget: 962 k€ (JDN, 2018)

Climatic Zone [Köppen]: Cfb - Temperate oceanic climate | Temperate | Without dry season | Warm

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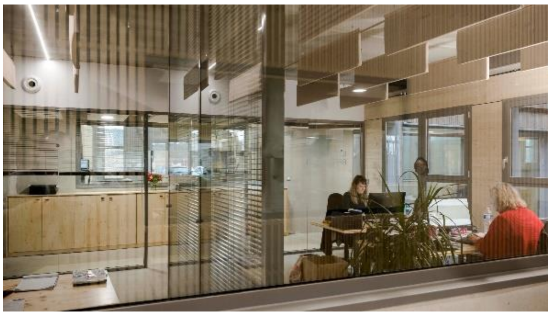
Further Images & Plans of the PEB

Image 5



Photograph of an office space in the Aerem factory
[Source: © SEUIL ARCHITECTURE]

Image 6

Photograph of a production area in the factory
[Source: © SEUIL ARCHITECTURE]

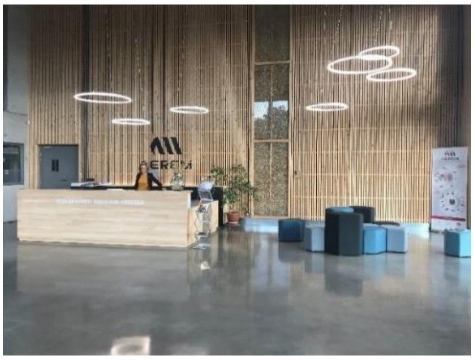
Image 7

Office spaces, separated from the factory floor
[Source: © SEUIL ARCHITECTURE]

Image 8

Photograph of manufacturing machinery inside the factory
[Source: © Stéphane Brugidou]

Image 9



View of the factory's reception area
[Source: © SEUIL ARCHITECTURE]

Image 10

Photograph taken outside of the factory building
[Source: © SEUIL ARCHITECTURE]

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