Towards Climate Neutral Buildings – Case Study of Positive Building in Brussels: Gare Maritime project

T Bockelandt 1 and N Jamali 1

1 Boydens Engineering (part of Sweco), Noordkustlaan 10, 1702 Groot Bijgaarden, Belgium

Abstract. The Gare Maritime is a former freight station in Brussels that has been vacant for quite some time. The exceptional architectural features of the building have encouraged the owner to maintain and restore the building and create commercial and office spaces. To this end, the large hall is renovated into a well-insulated envelope in which the office volumes are placed independently. These spaces are climatised by using a geothermal loop with ATES to which individual heat pumps are connected: Cooling is provided in a passive way and heating is done through the heat pumps. A 3MW of PV-panels installations is on the existing roof structure. By means of the insulation package and an intelligent control system for openable parts of the building envelope, a comfortable indoor climate is created within the hall itself in which activities can take place for most of the year. The moderate temperature in the hall leads to a low energy consumption of the built-in volumes and losses to the outside environment are drastically limited. The ventilation is supplied in all spaces using a mechanical system. Inside the office-volumes, a perfect flexible climate is guaranteed by means of chilled ceilings, which also act as acoustic absorption material. Large window-openings maximize the benefit of daylight penetrating the building. By using variable frequency pumps, variable air volumes and daylight controlled light fixtures and sensors; the energy use of the building is minimized. Besides the 100% refurbishment of the existing structure, the design team developed a structural strategy of prefabricated, wooden constructions for the built-in office spaces, making it a perfect example of the reduction of the use of natural resources and maximizing the amount of absorbed CO2. To come to the overall strategy of this renovation, numerous simulations, brainstorms and gathering of references were conducted from the early-stages. The start design parameters of the project were determined through simulations before the elaboration of an architectural design. This process allowed the client to take decisions based on robust data relating to attainable comfort, investment costs and environmental considerations. Overall, the project is Energy Positive Building

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1. Presentation of the project

The Gare Maritime is a former freight station in Brussels that has been vacant for quite some time. The exceptional architectural features of the building have encouraged the owner to maintain and restore the building and create commercial and office spaces; The goal of the project owner is to create a dynamic neighbourhood through the development of a mixed program (working, shopping, eating, entertaining...) and that will bring visitors to the site through public and private events.

Gare Maritime targets to be an iconic gathering places by the construction of 12 new volumes under the existing renovated 20th century shell.

Figure 1. View of the North-East Gates of Gare Maritime

Figure 2. Postcard with interior view at the Gare Maritime

The layout of the new layout were designed to integrate into the urban context and to be inline with the existing architectural envelope fabric. The 12 volumes are placed at the perimeter of the existing structure to create a monumental square that will host green elements and allow the visibility of the existing historical structure; two smaller volumes are positioned against the short facade at Rue Picard.

The open space, not occupied by the new volumes, is organized threefold.

In first place a monumental central event space below the high pitched roof for very diverse events. On the east and west sides of this central space, are designed green boulevards that function as the main circulation arteries through the vast space, and allow at the same time for cosier places of rest.

Two main streets with a width of approximately 7m are crossing the site in the north-south direction, giving access to the different functions in the new volumes, and connecting Gare Maritime to the surrounding neighborhood.

On a sustainability level, the ambition of the team was to target a positive building concept and to aim for a BREEAM “Excellent” certification.
2. Design process

2.1 Shaping the outer shell envelope

From the beginning of the design of the site, the focus has been made on the functionality and properties of the hall. The ambition of the project owner is to develop the hall as a place of social connection, culture and nature. The nature of usage of this hall pushed the project team to focus on the human comfort which is lacking in such an industrial space. Therefore, prior to the elaboration of the architectural design, a thorough analysis of the hall has been made. First of all, the definition of the thermal performance of the hall. The goal is to find the balance between a adequate thermal comfort for outdoor spaces and a low energy consumption. To do so, several scenarios were conducted to understand the behavior of the hall.

Three types of concept were analyzed. They were separated in three color groups:

- Blue: Hall as industrial building, no heating and no ventilation – Scenarios 1 to 4
- Green: Hall as unheated volume: Ventilation through foul air from building – Scenarios 5 to 8
- Red: Hall as heated volume (16°C), ventilation through foul air from building – Scenarios 9 to 12

Within these groups, same insulation layouts were simulated according to different projects setups and local regulation.
Figure 4. Scenarios simulated for the hall design

The simulations were conducted in the software TRNSYS 17 for a model including the whole project sites with potential 2-3 storeys internal buildings. In total, 13 zones were taken in account and the analysis were taken in account for an entire year.

Figure 5. TRNSYS model of the hall

The comparison was made on temperature distribution over winter and summer season for all configuration in relation with the energy use.

To develop the synergy with the outdoor environment, free cooling scenarios were simulated as well. Free cooling is operated through automatic windows and bring an amount of fresh air equivalent to three air changes per hour. They open at the following conditions:

- Temperature hall > 26°C
- Free cooling during occupied period (Monday → Friday 8u00 ->18u00)
- Wind speed < 4m/s
On visual comfort level, the hall has a great configuration for daylight availability. The openings on the facades and on the roof are big enough and get enough daylight in the hall. However, the configuration needs to be adequate for the implementation of internal buildings. Therefore, the shape of the internal volumes were introduced in accordance to the existing glazing. To be able to compensate the self-shading, additional glazing were assessed and considered.
From the first analysis conducted, several steps were identified on the design process needed to be followed to meet the requirements of a comfortable outdoor sheltered volume:

- Insulating the internal building blocks and the outer shell of the hall
- The use of natural ventilation brings the temperature down during hot period of summer
- The roof works as a very tough filter on the available daylight. Adding skylights will not have a large impact on energy consumptions and brings daylight inside the internal spaces

Furthermore, the implementation of the skylight has a double functionality. With such a redevelopment, the Gare Maritime will undoubtedly attract crowds in Brussels. To ensure the safety of visitors and users, an innovative smoke and heat extraction (SHE) system was installed. The project involved integrating 800 smoke extraction systems into the glass roof equivalent to 2,800 square meters of opening elements. In practice, the solution implemented consists of a frame construction made of aluminum profiles with thermal breaks, tested in accordance with the European standard EN 12101-2 and provided with a CE label for comfort ventilation.

Obviously, the openings provide smoke control via automatic smoke and heat extraction, but also provides a constant supply of natural light via the transparent glass panels and constant natural ventilation.

### 2.2 Design adopted

The volumes follow the basic column span of the existing structure (12m) with three bays (length of 36m in total); the volumes take the depth of one high (26m) and one low (12m) pitched roof.

Important to note is the visual and constructive disconnection between the existing structure and the new volumes.

The large volumes have a ground floor, first floor and a “creative attic”, a duplex with mezzanine below the high roof. A central core accommodates a generous staircase, elevator, sanitary and shafts.
A series of stairs on the lateral elevations outside the new volume allow for fire escape and secondary circulation.

The floors themselves are all designed on a 1m20 square grid, and can be fitted out in different ways; with one or more tenants on per floor or per volume. The different volumes are connected to each other on the first floor as a bridge over the transversal streets. These connector spaces can be used in various ways.

2.2.1 New Volumes. The volumes have two types of facades. The two lower levels are enclosed by a wooden curtain wall with transparent glazing; large protruding and retracting boxes on ground floor animate the green boulevards, and allow for the placement of necessary doors and shopfronts. The two upper levels are enclosed by a steel silver coloured curtain wall with transparent glazing for its juxtaposition against the existing steel roof structure. The curtain walls follow the 1m20 grid on all elevations.

![Figure 8. Internal volumes configuration](image)
3. **Sustainable concept**

3.1 **BREEAM certification**
From the conceptual design of the project, BREEAM certification was adopted as an appropriate project methodology. Sustainability was included in every decision from a holistic perspective. The general idea of sustainability is a multi-faceted field, which can have a far-reaching impact in each of the classical design disciplines.

A BREEAM excellent score is targeted. The outer shell - the historical part – has been assessed by a BREEAM Refurbishment program and also there is a BREEAM excellent score targeted for the internal volumes.

3.2 **CLT**
The internal buildings were developed to align with the sustainable vision.

“The buildings are formed around central cores of spruce cross-laminated timber (CLT), with a structure of columns and beams, and floors of CLT panels with glulam ribs. The latter enabled longer spans to be achieved than would normally be the case with timber construction – up to 8.4m in the buildings themselves.

To be able to connect them on site and avoid transporting large glued pieces, the team designed a screwed connection that could be made on site without any special conditions. These ribbed floors, which act compositely, accommodate services and eliminate any need for cable holes in the ceiling beams, except at the ground floor where there were restrictions on excavation depth.

The spatial constraints of the existing building limited the options at times – the upper mezzanine floors are cantilevered out from the core and a special joint had to be developed to support them. Each building also incorporates four high-strength beech laminated veneer-lumber beams, which are employed where mid-span columns need supporting, the beams must resist very high levels of shear stress, or beam height is restricted. Spruce veneer on the beech beams ensures a match throughout. The beams with the highest loads are connected using perforated steel HSK plates, which are milled into the wood and glued with epoxy resin to ensure they are completely invisible. The same joints were used for the wooden stair stringers”¹ (Russell).

![Figure 9. Cut-through rendering of the complex – Source: Extensa Group](image)

3.3 **Green spaces**
There is no doubt that human civilization harmed the degree of variation of organisms in different ecosystems, natural communities, and habitats, the so-called biodiversity. One of the key drivers for the loss of global biodiversity is building development. There is insufficient attention paid to integrating biodiversity policies with strategies for urbanism. Mass housing, infrastructure development and social programs generally pay scant regard to connections between biodiversity and human well-being.
The development of green spaces was developed inside and outside the hall in this way of thinking. Especially, it is bringing improvement of the urban heat island effect on site, a cooler building in summer, fewer heat losses in winter and a lower energy consumption in cooling and heating season.

Figure 10. Green spaces in the hall of Gare Maritime

4. **Technical Concept**
A low energy demanding building is developed through a renewable energy concept. The goal was and is to reach a Positive Building Standard.

Figure 11. Sustainable and technical concept of Gare Maritime
4.1 Heating and Cooling production

Heating and cooling production in the project is based on 10 open-loop geothermal wells of a depth of 140m. They are supplemented with an adiabatic passive cooling system installed in the Air Handling Units that uses evaporated rainwater to cool the air pulsed into the new volumes.

This aquifer thermal energy storage (ATES) is an energy storage that will supply the whole site with cold and heat. The underground aquifer has an average temperature of +/- 9-13°C which can be used as a source for passive cooling and also for the heat pump. The latter will bring the temperature to a higher level to feed the heating system. This underground heat is always available, CO2 neutral, free and can be regenerated forever.

Important is that the heat retracted from the soil for heating (wintertime) is in balance with the heat injected to the soil (summertime). Large seasonal efficiencies can be achieved (SCOP in heating +/- 4,5 and >20 in cooling).

![Figure 12. Principle scheme of the ATES system](image)

4.2 Ventilation

The best air quality class has been selected for the buildings, under the standard NBN EN 13779. A minimum of 54m³/h has been provided per person, corresponding with an IDA1 class.

To limit the ventilation losses, a ventilation system type D is set up. This system supply and extract the air mechanically and have a recovery unit to extract the heat from the exhaust air coming from the building with the fresh outdoor air. With such systems in large air handling units efficiencies to 70% are achieved. The recovery unit is bypassed to use ‘free cooling’ during summertime. In all occupied spaces the ventilation will be CO2 controlled.
4.3 Photovoltaic Panels
On a sunny day, the solar panels provide 100% of the power needed in the occupied spaces. The Gare Maritime is energy positive, as it uses the latest renewable energy technologies. 10,000 photovoltaic panels, covering a surface area of 17,000 m², and building-integrated photovoltaic cells (BIPV) power the entire station.

![Photovoltaic panels on the roof](image)

**Figure 13.** View of the photovoltaic installation on the roof

5. Conclusion
The Gare Maritime is a project that has been conducted from the beginning to be sustainable. The effort and the out-of-the-box thinking led the project team to make the site an exemplary design across Europe for a renovation of a freight train station. The project enroll itself in the climate change movement aspired by the European Union for the building industry. In a context where renovating the European building stocks is necessary, the project show that solutions are available and innovation can be introduced in the building lifetime.

References

1 Russell, H. (n.d.). *Projects: Gare Maritime, Brussels*. [https://www.building.co.uk/projects-gare-maritime-brussels/5105333.article](https://www.building.co.uk/projects-gare-maritime-brussels/5105333.article).