Abstract
For a design and build competition of a new 80.000m² office building in Belgium, dynamic simulations were used from sketch design on to develop a high performance façade that complied to all the requirements defined by the client.

Key Innovations
- The presentation of this case gives insight in the use of simulations for specific multidisciplinary design choices in designs of large buildings.
- The presentation shows a practical step by step methodology to optimize the façade with various combined simulation tools.

Practical implications
Modern building’s expectations are high and sometimes the requirements are overlapping (e.g. Daylight vs energy use). By following a roadmap an optimal design can be achieved wherein the balance between the different requirements is found.

Introduction
A competition has been launched to build a +/-80.000m² mixed-use building in Belgium. The client requirements were high; class A comfort, BREEAM daylight compliance, low energy consumption, light building structure, maintenance friendly and, above all, a flexible and functional building.

The project is situated on a site where a building of monumental value is integrated in the scope of works of the project. This project is located next to the largest railway station in Belgium, in the heart of Brussels.

The project is to be developed 50% as new building and 50% as renovation.

Figure 1 shows in grey the building perimeter. The red frame indicates the new building part the lower (in black frame) is the renovation part.

Where the existing building is located, the building has a double width, compared to the upper/new building part.

As a starting point, the idea of the architect was to create the new building with minimal impact on the existing infrastructure and neighbouring surroundings.

Next to that main idea, the cladding material should be resistant to flash rust (coming from the rails) and easy to maintain.

A curtain wall façade was the obvious starting point of the design. Simulations were used to optimize the amount and location of the glazed elements, enhancing thermal and visual comfort while keeping the glazing as cladding material.

Road map – methodology and results
Since the existing building is protected, there are limited façade changing possibilities in that volume. The focus has been on the new volume (Figure 1, red bounded volume). To prevent overheating, a reduction of the building’s window to wall ratio (WWR) was required.

Based on the following model two simulations have been performed to compare the performance of a WWR of 30% and 50%. (in square and round windows, lower two floors => 50%WWR; upper two floors => 30%WWR)
The first simulation performed was a daylight calculation on the full width of a building floor to determine the specifications of the glazing to reach the BREEAM daylight requirement - a daylight factor of 2% in the occupied spaces. Simulations are performed by Rhinoceros 3D (modeling) and grasshopper + honeybee for programming.

As one can see in Figure 3; the internal layout should be organized in a way that rooms without any daylight requirements are located in the middle of the building (e.g. Storage rooms, toilets). On the other hand, landscape offices over the full width of the building create maximum flexibility for internal layout.

Based on these first simulations the first internal layout was developed.

A similar simulation has been done for the middle part of the building; where the width is 30m and a 100% glazed façade has been developed.

The next step in the process was to assess the thermal comfort. For that a thermal simulation in TRNSYS was performed, taking in account a climate ceiling to reach the comfort requirements. The comfort analysis was done for two locations; one close and one further away from the façade as indicated in figure 4 (red dots).

Since the façade is oriented towards the railways, the flash rust has an effect on the maintainability of external sun screens. For that reason the impact of a screen was simulated to determine if an external screen could have been avoided.

Three conclusions were drawn from this analysis:
1. The impact on the shading on the southeast façade was clearly visible.
2. The difference between a person close and far from the façade is insignificant.
3. Sun shading is mandatory to maintain a good indoor comfort.

To reach class A comfort we could conclude that the control of the system (climate ceiling) is too slow, and to keep respect the narrow comfort bounds a faster-reacting system is required.

Based on the results of these simulations the architect has developed the façade to reach all requirements.

Further calculations have been done to create the combination of fritted glass, insulated (opaque) parts and internal, high performing solar screens.

Finally the energy demand of the full building was simulated using IESVE to prove BREEAM compliance in energy use.

**Conclusion**

The developed façade made it possible to reach a building demand of 13kWh/m² for heating and 6kWh/m² for cooling, a passive building definition; including the renovated building part. As end result of this combination of simulations a visually fully glazed façade (seen from the outside) but insulated and provided with internal solar shading could still result in optimal indoor comfort in a passive way.