**Proceedings of 11th Master Conference: People and Buildings**
University of Westminster, 16th September 2022
Network for Comfort & Energy Use in Buildings: https://www.nceub.org.uk

# Green Facade Features for Office Buildings in The Future Climate

**Wilanda Rachbuakhao**[1]

[1] MSc Architecture and Environmental Design, University of Westminster, London, UK, r_wilanda@hotmail.com

**Abstract:** A facade's refurbishment is essential for London 2050 to achieve the zero-carbon goals since facades influence more than 50% of the energy consumed. The green façade strategy is passive solution to satisfy this issue due to its benefits. This work aims to evaluate the impacts of green facades on thermal comfort and wellbeing quality inside the environment of office buildings in London. Several scenario studies with various conclusions about how energy and daylight react to changing input conditions are the result. The proposed study would utilize green façades in office buildings to achieve useful natural daylight, thermal performance enhancement, and energy savings to adapt to London's future climate. The findings suggest that the application of green facade features with natural ventilation reduces energy consumption and enhances thermal performance with fresh air due to their ability to filter air. Additionally, depending on orientation, it can eliminate uncomfortable glare in spaces.
**Keywords:** Green façade, Plants, Office buildings, Energy saving, Thermal performance, Glare

## 1. Introduction

To understand the trend of façade building in London, the effect of the UK climate is investigated. According to the Koppen climatic classification system, Britain, which includes London, is classified as a Marine Mild Winter Climate (Cfb), which is temperate, lacks a dry season, and has a warm summer. (Peel, Finlayson, & McMahon, 2007) Additionally, London has the Urban Heat Island Effect, when city temperatures can be much higher than those in the nearby countryside.

Besides the seasonal temperature changes, many of London's office buildings are in cooling mechanical systems for much of the year because of their high densities and deep plans. Due to the possibility of a warmer climate in the future, extra caution must be taken to minimize cooling loads, the most evident of which is that caused by solar heat gain through large amounts of glazing.

By the occupants' activities or by mechanical systems, the façade would filter daylight and fresh air from the outside as required in accordance with the seasonal changes. The goal was to drastically cut the energy budget for the buildings that were planned. The precise definition of comfort standards should be somewhat modified within working spaces and buffer spaces to enable temperatures to fluctuate significantly, especially in the summer, in order to achieve low energy performance in practice.

The use of green technology is being encouraged by a growing global interest in sustainable construction. In addition to serving as shading devices, building envelopes also play a contribution. Vegetation can improve the energy performance of a building's walls as an additional element. Greening reduces energy use for air conditioning in the summer and improves thermal insulation in the winter, which improves building energy efficiency in cities (C.Y. Cheng, 2010)

According to a report from the Greater London Authority's London Plan and Environment Teams, living walls can greatly decrease a building's façade temperature by providing shade from the sun. The overall area that is shaded and the evapotranspiration effects of the vegetation, rather than the climber's thickness, determine how efficient this cooling effect is. When combined with the insulating effect, diurnal temperature changes at the wall surface can be lowered from between 10 °C and 60 °C to between 5 °C and 30 °C.

Consequently, it is common to come across building designs for various projects that utilize significant amounts of vegetation, in addition to existing buildings using such elements. The debate that this work hopes to spark is regarding the actual effects of using plants for comfort and human health in interior office spaces.

The advantages of applying green facade succeeded in several exiting buildings with the use of plants. However, the ability of different types of green wall should be examined to define the best scenario that suit for future climate. The aim was to explore the installation of different typologies of green facades creates positive impacts on energy consumption and must be achieved to have a comfortable and sustainable office space.

## 2. Design scenario

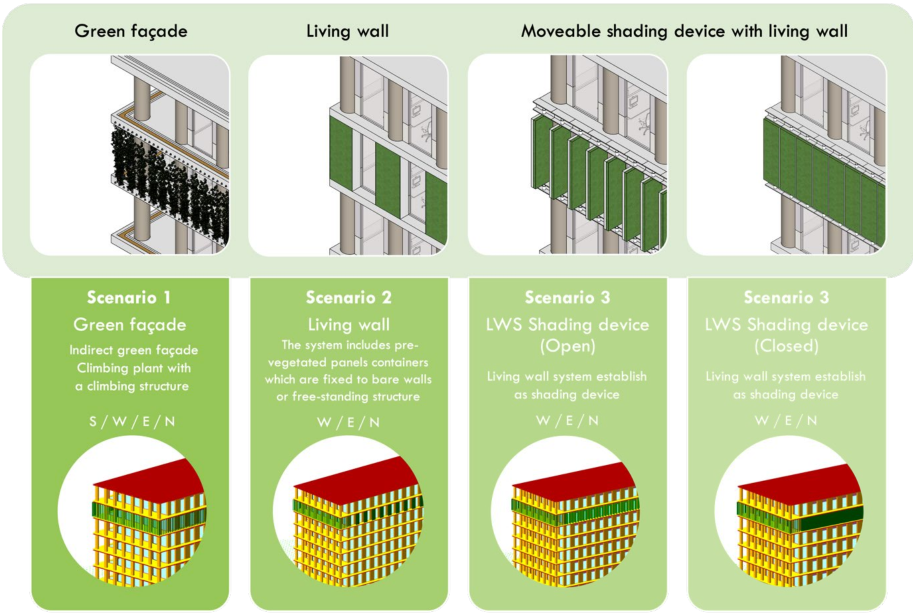


Figure1. Four design scenarios

Thermodynamic simulations will be used to analyze the office typology with different green facade design scenarios through the model of the base case with the same internal gains, building elements, zone analysis, and building fabric that were identified as the primary factors from the previous chapters. As a result, multiple green facade scenarios are evaluated in order to compare and describe design outcomes.

## 3. Methodology

A TAS analytical model was built as a shoebox to monitor the thermal performance of the building through façade design variations. The shoebox is modelled to reflect a typical office space, generated from a floor plan, and an open office typology is taken into consideration. In this case, the length is set 6.8 meters which is equal double of the floor to ceiling height (3.4m). The width of the model is set to 9 meters to fit three windows.

The level of the simulation model is on the 7th floor of the building due to the analytical work findings for the effectiveness of integrated green façade strategies, and it is the average height of a medium-sized commercial building in an urban area that is influenced by environmental factors. However, the surrounding obstacles were not considered in this investigation.

The input of internal conditions and construction for a typical office with a simplified value to nearly match the recommendation of LETI. For internal gains, the indicator measures of occupancy, equipment, and lighting gains are calculated according to basic office typology. The people and equipment gains are 8 W/m2 based on the Gridiron building results (7.5 m2/pp). The lighting gains are for LED lights at 12W/m2.

The materials of construction of the building frame are typical for commercial buildings following the LETI document. The internal floor/ceiling is divided as follows: typical ceiling tiles, air gap where the services are located, concrete slab and screed (U = 1.39 W/m2K).

The facade glazing area is double-glazed and insulated with Argon gas with the following dimensions: 6-12-6mm (U = 0.15 W/m2K). The G value indicates the amount of solar energy transmittance that was used. For the base case, a G = 0.362 was assigned (LETI recommended range of 0.3-0.4) for all orientations. The U-value of the external wall applied is 0.15 W/m2K following the LETI recommendation. The balcony floor input U-value is 0.25 W/m2K, which includes flooring screed, polyurethane 3 inches and 100m of cast concrete.

The design scenario of green façade application is generated into three scenarios in the figure above. The internal gains and the building construction input are the same as in the earlier simulation's base case scenario. Some material values have been altered, and a green facade has been included in the simulation of the design scenario.

For scenario1 the green façade of ivy plant climbing has to be simplified into a model simulation. To determine the possibility of foliage density on façade greening with appropriate plant space and climbing structure in 1 façade unit area, the first step is modelling in the sketch up program. Following that, the elevation view of a unit façade is then exported as a black-and-white image. The total area of vegetation that covers the greening of the façade is then calculated using the grasshopper 'picture simplified' on rhino. After calculating the area of the plant per unit façade area, it is shown that 60% of a unit façade area is taken up by plants. When adopting the TAS model, the shading element has been produced by employing 60% of façade's area for the shading element. After inputting the internal gains and construction, implementing the living wall construction into the shading elements with a U-value of 0.55.

Moving to scenario2, the green façade scenario2 is modelled on TAS the same as scenario1 with the shading device only on the south elevation. Following that, changing the construction of the external wall into the external wall + living wall, which has a U-value of 0.11 as in Figure 54, After this, the internal gains have been input as in scenario 1.

For the scenario3, implementing the living wall construction into the shading elements with a U-value of 0.55. The internal gains have then been entered as in scenario 1. The shading component is positioned at different angles, including 180 degrees open and 90 degrees closed, to simulate scenario 3.

All models are simulated for different cooling systems in various cooling modes for office buildings. The outcome findings are compared for different types of scenarios in three seasons. The objective of this study chapter is to analyze and investigate energy use in different cooling modes of office buildings with base case, scenario1, 2, 3(open), 3(closed) in three seasons, including winter, midseason, and summer, in a future climate.

**Limitation**

It is important to point out that simulations of vegetation using this sort of software are extremely rare since plants are living things whose qualities and traits are constantly changing, making it impossible to treat them as materials with a constant U-value or even a regular size. As a result, the experiments done on TAS were predicated on speculative circumstances that adding plants may provide. It is feasible to claim that the research carried out using this software are an imitation of a green façade feature rather than an exact replication of reality.

## 4. Outcome

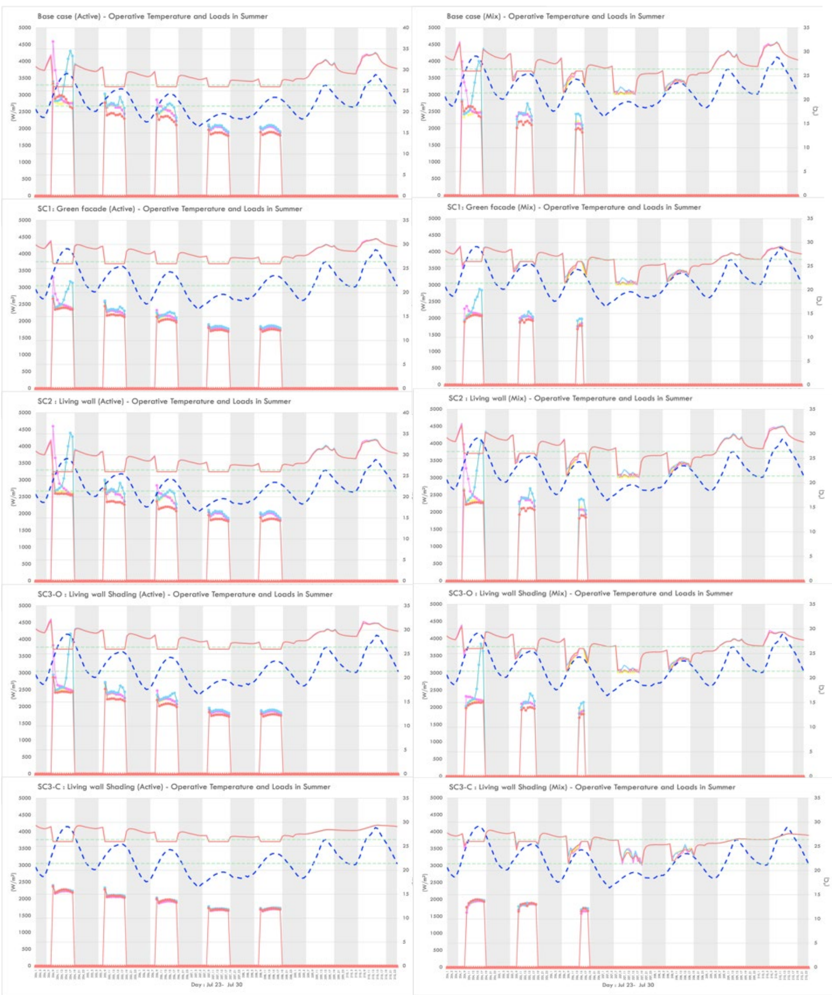


Figure 3. Active & mixed mode temperature in summer

| Reduction of Cooling Load (%) | SC1 : Green façade | SC2 : Living wall | SC3 : Open Living wall Shading | SC3 : Closed Living wall Shading |
|---|---|---|---|---|
| By installing Green façade | 17.59% | 3.00% | 15.39% | 26.34% |
| By installing Green façade + Natural ventilation | 82.75% | 77.93% | 82.48% | 81.78% |

Figure 4. Reduction of cooling load

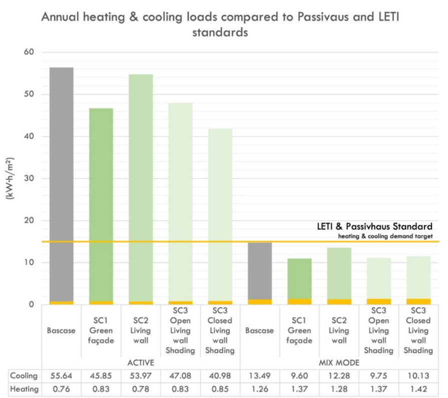


Figure 2. Annual loads

To conclude these four studied cases of thermal performance, analytical work cooling loads were calculated for all the orientations (figure 129). Annual cooling loads are compared with the Passivhaus and LETI document thresholds, which specify that specific heating and cooling demand should be ≤15kWh/m2 yr.

The annual load comparison shows in the figure, the annual cooling load of scenario1 with contributing natural ventilation is reduced significantly from the base case of 82.75 percent. However, the annual cooling load from active mode analysis of the base case to scenario1 dropped slightly, about 17.6%.

The annual cooling load of all greening studied cases cannot reach the benchmark without applying natural ventilation. Scenario3-C can reduce the annual cooling load with active mode by 26.34% from the base case, which is the highest reduction in active mode simulation. While the reduction of cooling load during a year in scenario1 with mix mode can reach 82.75% in comparison with the base case.

## 5. Illuminance and Glare analysis

To understand the impact of applying green façade on glazed window, the illuminance level and glare analysis is examined. This study chapter's goal is to analyze and research the impact of green façades on daylight levels and glare reduction during various times of the year without green facades and with SC1.

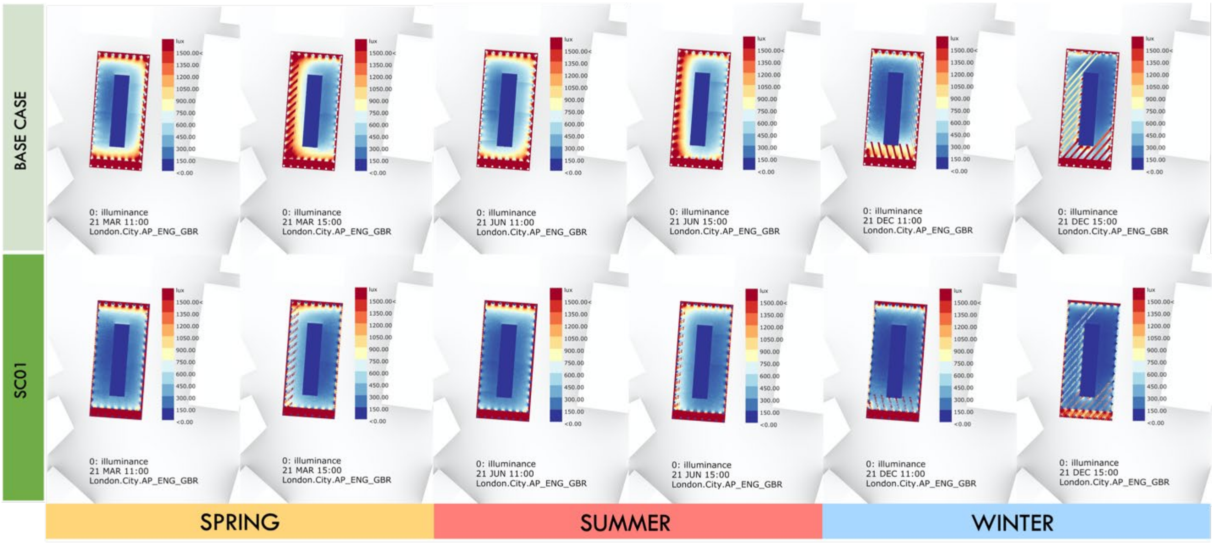


Figure 5. illuminance analysis results in three seasons

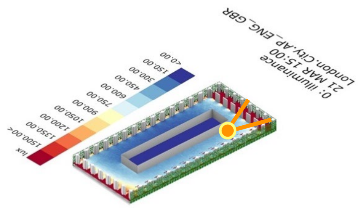

Figure 6. Viewpoint for glare analysis

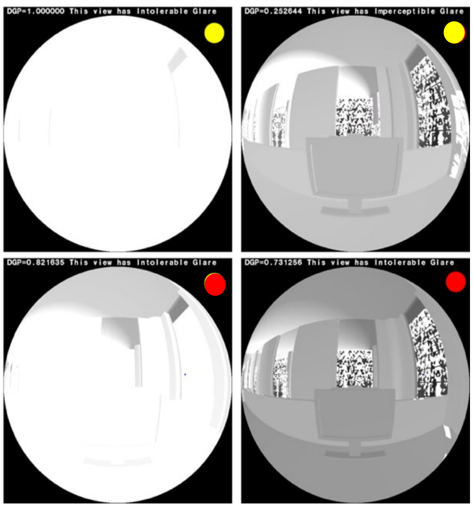


Figure 7. Glare on base case(left) and scenario1

To complete the tasks, they are in charge of, people require a suitable workspace. This means that they require enough lux level to safely work their tasks station and move around the workspace. They also need enough light to focus their jobs, such as computer works and paperwork. Employee perceptions of inadequate light at work environments have a negative impact on job satisfaction, productivity, and long-term sick leave.

The SC1 green facade scenario succeeds in lowering DGP, which improves the visual comfort of the working environment inside the office building and nearby buildings. This is due to the fact that covering plants reduce the reflection of glass facades, which not only reduces glare inside the office but also has an effect on surrounding buildings.

To sum up, the greening application on the glazing facade results in a green façade that obviously affects the reduction of lux levels in some areas, leading to the increasing use of artificial light, which leads to the production of more lighting gains in offices. However, it can prevent the glare issue from the high level of lux level in some areas. This is because the glare problem can lower employee productivity and health.

## 6. Conclusion

This research demonstrates the critical contribution that a green facade makes to an office building's thermal performance, energy efficiency, productivity, and occupant well-being. The typical office building typology has a high level of energy consumption, particularly cooling load, even in the winter, according to the future climate in the urban area of London. It also presented issues with the hotter temperatures of the future climate, the thermal discomfort brought on by solar radiation, and the visual discomfort brought on by daylight and glare, all of which plants can assist in reducing while taking into account its limitations.

Additionally, the LETI-recommended building design measures state that London will achieve net-zero carbon emissions in 2050; as a result, a medium-sized commercial building can adapt the design recommendations into a mixed mode system with a green façade, which can reduce a significant amount of cooling load by 80% when compared to the base case in mechanical systems.

For the typology of office buildings, the combination of a green façade and a mixed-mode system with natural ventilation is appropriate. They can serve as an effective air filter, reducing dust and pollution in the fresh air that enters the interior space. This is the main argument for why adding a green façade is preferable to a general shading device, even though there are many conditions to be concerned about. In addition, there are numerous advantages in terms of preventing glare discomfort and improving views with greenery.

In conclusion, it is essential to integrate green façade features with a mixed-mode cooling system (natural ventilation) in order to lower emissions, lower energy demand, improve thermal performance, and boost occupant productivity and visual comfort. This study demonstrates how the design of a green façade system depends on a number of factors, the most crucial of which is a building's fabric that is climate-responsive in the future.

## 7. References

Anon., 2020. LETI Climate Emergency Design Guide. [Online] Available at: https://www.leti.london/cedg

Anon., 2008. Living Roofs and Walls Technical Report: Supporting London Plan Policy, London: Greater London Authority.

C.Y. Cheng, K. K. C. L. C., 2010. Thermal performance of a vegetated cladding system on facade walls. Building and Environment Volume 45, Issue 8, pp. 1779-1787.

Anon., 2008. Living Roofs and Walls Technical Report: Supporting London Plan Policy, London: Greater London Authority.

Anon., 2014. Health, Wellbeing & Productivity in Offices The next chapter for green building, London: The World Green Building Council.

ING, W., 2021. Is the boom in green roofs and living walls good for sustainability? From architectsjournal: https://www.architectsjournal.co.uk/news/is-the-boom-in-green-roofs-and-living-walls-good-for-sustainability

Peel, M., Finlayson, B. & McMahon, T., 2007. Updated world map of Koppen-Geiger climate classification. Hydrol. Earth Syst. Sci, p. 1633–1644.