**Carbon Lighters 2023**

**Concept and Program**

To help achieve Houston’s first Climate Action Plan (CAP) to make Houston carbon neutral by 2050 in accordance with the Paris Climate Agreement, several design parameters were analyzed. Given the size of the existing building and its unique location near the NRG Stadium, the repurposing of the space serves the needs of the area by encompassing multiple and diverse uses. The urban analysis of the site led to the distinct character between the eastern and westernmost sides. On the western side resides the existing event/sports facilities adjacent to a more industrial urban context, while on the eastern side, we meet the edges of the Medical Center, residential areas, and the connection to the rail lines. This suggested a stronger connection with the city to the east by introducing a promenade that serves as a grand entrance to the building. At the same time, preliminary energy studies suggested that the east was the optimal orientation to create an opening into the existing open volume by removing part of the concourse, which improves self-shading and natural ventilation potential.

The programming of the space was driven by the neighboring uses of the NRG stadium and the newly introduced eastern promenade to the city. The main uses of the new design are Retail and Restaurants, a 500-room Hotel, a Botanical Garden, and a Museum of the Astrodome. The concourse areas are kept as existing but occupied partially to reduce operational energy. The outermost layer of the building is converted to sizable semi-outdoor spaces which act as additional shading & thermal buffers and, at the same time, augment the flexibility of the indoor spaces and their connection to the outdoors. The first level accommodates all Retail, Creative Spaces, Restaurants, and Bars, activating the street level and creating the opportunity to traverse through the site in virtually all directions. Levels 2 to 4 are dedicated to the Hotel areas that are thought to serve the multiple events taking place at the site. The top floor hosts a newly introduced Museum of the Astrodome, where memorabilia and sports history will be displayed, and augmented reality will use the building as a backdrop for recreating famous historical events that occurred inside the facility. Finally, the central area of the building is enclosed in a radius to host a Botanical Garden with at least three scales of habitat heterogeneity through vegetation selection in Houston to provide a multi-sensory experience as a focal point of the redevelopment. An underground parking area using the existing below-grade structure serves all areas' parking needs.

**Systems**

A 20’ thermal buffer at the outer ring of the concourses is introduced in order to deflect direct sun. The existing skylights are replaced with ETFE with a fritted translucent layer with a SHGC of 0.25 and a VLT of 62% while keeping the same geometry. The LPD was reduced between 30% to 40% as compared to the current building energy code, and all spaces have photosensors and occupancy/vacancy sensors. The Hotel public areas, Museum, and Retail have mixed-mode ventilation with dedicated outside air systems with enthalpy wheels for humidity control. The Hotel rooms are conditioned with 4 pipe FCUs operated by the guest with key card control. The Botanical Garden is only treated for humidity and uses displacement ventilation, delivering air low and slow. Under the Botanical Garden, there is a thermal labyrinth that will precool the incoming air. The thermal labyrinth is a ventilation system that pulls in outdoor air through an underground labyrinth-shaped concrete structure as part of the building itself. Through heat exchange with the ground, this system can pre-cool and pre-heat outdoor air in the summer and winter seasons. The remaining semi-outdoor space between the Botanical Garden and the concourse areas has spot cooling and displacement ventilation. Water from condensation is collected, treated, and used for irrigation. An extensive array of photovoltaics is designed in the surface parking lot areas, providing sufficient electricity to have the building be net-zero energy.

The central plant providing the heating hot water, domestic hot water and chilled water for the building is served by heat recovery chillers that provide heating and cooling with the heat rejection load reducing hot water demand. Outdoor air for all conditioned spaces is provided with DOAS with DCV and 4 pipe FCUs with hot/chilled water from the central plant. Domestic hot water is provided with a heat pump with the demand reduced by the heat recovery from the chillers.

**Carbon**

The original idea for the design intervention called for a limited disruption of the existing structure in order to minimize the impact on the existing embodied carbon. The proposed alterations aim at the energy improvement of the building with envelope optimizations that dramatically reduces the operational carbon footprint. For example, the total carbon is projected to be reduced by removing 12% of the existing structure and by introducing plenty of outdoor and semi-outdoor usable spaces. Also, by zoning the building into several diverse programs with distinct operations and comfort parameters, we were able to reduce the operational carbon footprint by almost half.

**Indoor Air Quality**

An extensive indoor air quality (IAQ) assessment was conducted to determine the most suitable seasonal conditions for implementing natural ventilation strategies across all spatial domains, including indoor, outdoor, and semi-outdoor areas. Moreover, a comprehensive investigation into wind directionality was concurrently undertaken, contributing valuable insights that played a pivotal role in shaping the overall design strategy. By analyzing prevailing wind patterns and understanding their impact on the site's microclimate, we were able to make informed decisions regarding the strategic placement and orientation of the main building opening to the east. A post-occupancy indoor air quality monitoring plan was established which includes sensor installation, data visualization platform with WELL/Reset recommended threshold to continuously monitor the real time indoor air quality. It can help diagnose the actual ventilation system performance and lower the probability of infection risk.

**Comfort**

Adaptive comfort studies without HVAC systems were conducted to understand the potential to have usable semi-outdoor areas and to establish the possibility of having mixed-mode HVAC use in the renovated indoor areas. The comfortable hours with different degree ranges were analyzed by implementing automatically controlled doors and skylights. Microclimatic studies further showed how the conditioning strategy for the semi-outdoor space between the Botanical Garden and the Restaurant/Retail/Hotel area would provide enough shading and optimal sun angles for plant growth.

The building is daylight autonomous in 97.8% (sDA) of its closed spaces. The simulated model also showed 0% ASE, indicating zero potential for creating glare problems. The results are attributed to the generous overhangs on the perimeter of the building and the introduced translucent roof layer on the skylight.

**Durability**

Climate change scenarios were considered in the design in order to assess the repercussions of increasing temperatures in the operational energy and carbon emissions. The new building seems to be able to endure those changes, showing only a 3% increase in operational energy and only a small portion of comfortable hours varies in the adaptive comfort model by 2050. The design also incorporates several outdoor or semi-outdoor flexible spaces that could be easily converted into additional indoor spaces if needed.