

## Sustainable green in the desert sands

The Hanging Gardens of Semiramis, one of the seven wonders of the ancient world, were a testament to the extraordinary. Today, creating a sustainable green oasis in the desert doesn't require miracles, but rather ambitious and conscientious planning. This was demonstrated by the lush Singapore Pavilion at the Expo 2020 in Dubai. Transsolar from Munich was responsible for the environmental concept.

### Expo in a Coastal Desert Climate

Dubai hosted Expo 2020, marking the first time an Arab country held a world exhibition. Despite a one-year delay due to the COVID-19 pandemic, the event attracted approximately 24 million visitors from across the globe with its theme of "Connecting Minds, Creating the Future." Throughout history, Expos have served as catalysts for innovative ideas, and Dubai's coastal desert climate presented a unique challenge. Typical new buildings are fully enclosed and air-conditioned - conditions that have come to be expected by locals. The aim was to design an open pavilion that could modify the existing climate without relying on air conditioning, creating a comfortable environment for visitors. The concept involved harnessing solar groundwater desalination to generate sufficient water for irrigation and implementing other measures to establish a locally pleasant climate.



### Visitors at the Heart of the Design

Architecturally, an expo strives to showcase the extremes of possibility. However, the Singapore Pavilion was not solely created for artistic expression; it placed visitors at the center of its design.

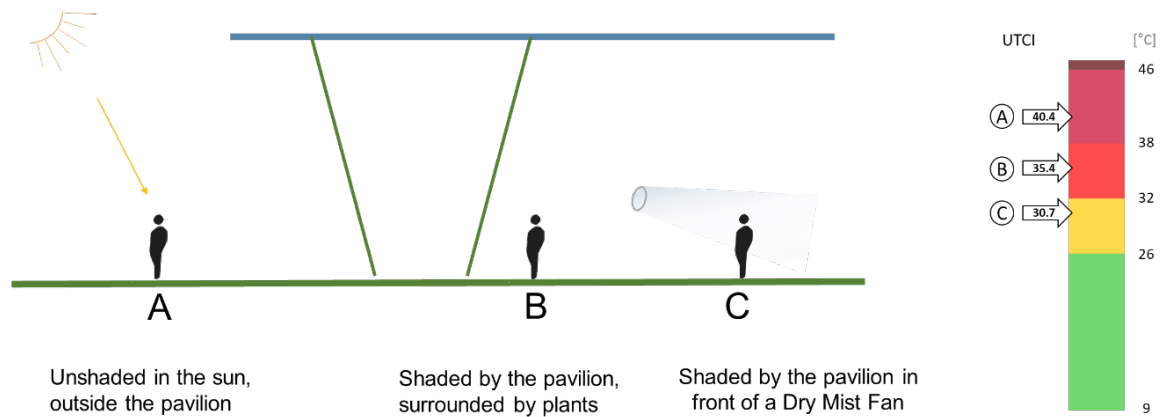
The Munich-based Transsolar team focused on two fundamental questions: Could passive measures and extensive planting be employed to create pleasant outdoor spaces within an open pavilion that replicated the tropical environment of Singapore in Dubai's climate? Additionally, could the pavilion operate autonomously using only renewable energy and water resources?

### Inspired by Singapore: Green "Climatecure"

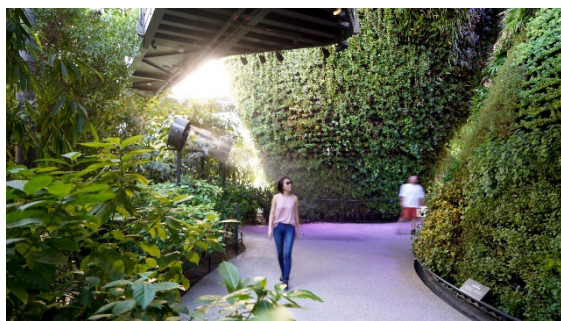
The project was developed in collaboration with Singaporean firms WOHA Architects and Salad Dressing landscape architects. WOHA Architects is renowned for its sustainable and vegetation-centric approach to architecture and outdoor spaces, which effectively moderates local climatic conditions for enhanced comfort. At the heart of the Singapore Pavilion were three cone-shaped structures that supported multi-layered vertical and horizontal planting, symbolizing Singapore's vision of a city in harmony with nature. All the plants were sourced locally from nurseries in Dubai. The cones also served as platforms for the Sky Market, where visitors could experience various events and exhibitions. The pavilion's roof, adorned with an expansive photovoltaic system, provided shade for the Sky Market and supplied all the energy required for pavilion operations.

### Cool Plants and Comfortable Spaces

After the completion of the pavilion, measurements confirmed that Transsolar's climate and comfort concepts, which were developed using digital models and simulation, translated effectively to reality. Visitors entering from the outside, where shade was scarce, experienced an immediate improvement in outdoor comfort as they ventured further into the pavilion.



The change in body language observed in visitors as they explored the lush green environment inside the pavilion demonstrated their positive response to the enhanced outdoor conditions. Technically speaking, the micro-climatic conditions inside were perceived to be approximately 5 degrees Celsius cooler than the outside temperature. This perception was quantifiable using parameters like the Universal Thermal Climate Index (UTCI). For example, on a hot October afternoon with a UTIC of 40.4 °C outside the pavilion, the UTIC inside dropped to approximately 35.4°C.

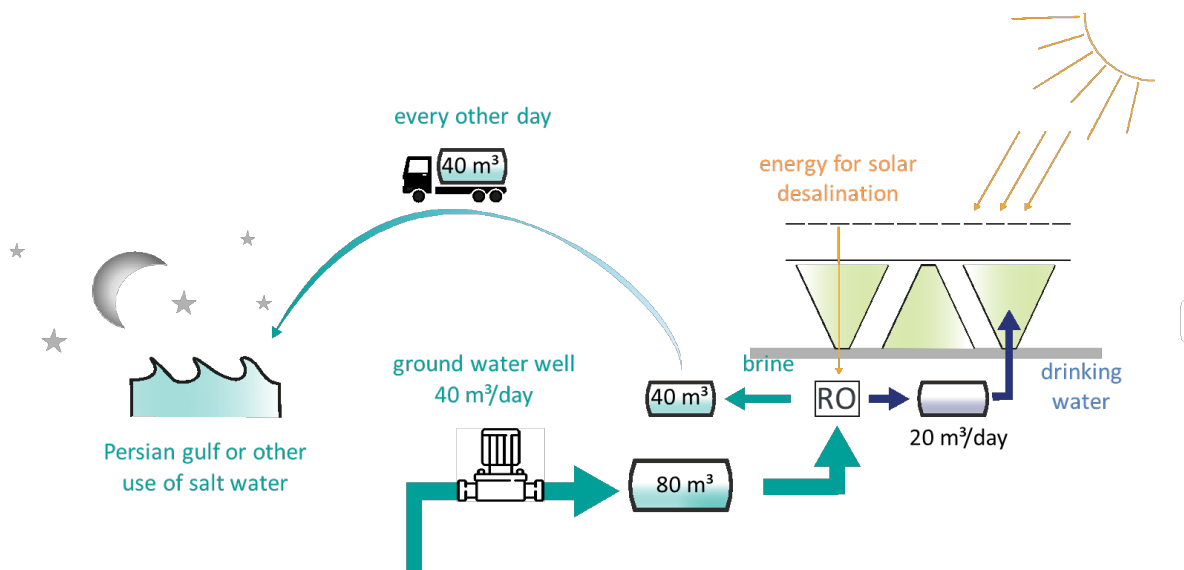


The cooling effect within the pavilion was primarily attributed to the presence of plants, which covered an impressive area of 700 m<sup>2</sup> on the ground, 1350 m<sup>2</sup> of vertical surfaces, in addition to 1770 hanging plant pots. The cooling impact exceeded the expectations set by the initial models, likely due to the combination of vertical greenery and the moist soil in which the plants thrived. The combined effects of evapotranspiration and soil evaporation resulted in lower air temperatures and cooler radiant environments.

### Dry Mist for Enhanced Comfort

As visitors ventured deeper into the Singapore Pavilion, the UTCI dropped by an additional nearly 5 degrees Celsius to 30.7 °C. This significant improvement was primarily achieved through excellent shading and the use of a Dry Mist system. Unlike conventional misting systems, Transsolar's innovative cooling system generated a refreshing breeze without wetting visitors. The system employed small, high-pressure nozzles and maintained a balanced ratio of air and water. While the system appeared inconspicuous, resembling typical fans, it provided a significantly superior micro-climatic performance. The Dry Mist system demonstrated remarkable energy and water efficiency, operating with an equivalent coefficient of performance of 20, while conventional air-conditioning systems in Dubai typically operate with a coefficient of performance ranging from 3 to a maximum of 5. Over 60 Dry Mist Fans were deployed throughout the Singapore Pavilion, obviating the need for any form of air conditioning. These two simple measures - abundant planting and the Dry Mist system - successfully reduced temperatures to a comfortable level for visitors.





### Solar Desalination of Groundwater

With thousands of plants requiring watering, the Dry Mist system consuming water, and the pavilion's general water needs, achieving sustainability was a crucial consideration. The water allocation provided by the Expo, which amounted to 0.5 liters per square meter per day, fell short of the Singapore Pavilion's requirements. The pavilion required ten times that amount. Positioned within the sustainability section of the Expo, the design aimed to showcase a net-zero-energy and net-zero-water pavilion, inspiring visitors with a truly holistic sustainable approach. Transsolar collaborated with the landscape designers to reduce water demand and developed a water concept centered around a groundwater well. By extracting 40 m<sup>3</sup> of saline water daily, the pavilion employed a solar-powered reverse osmosis system to desalinate it, resulting in 20 m<sup>3</sup> of potable water for daily use. This exceptional concept received approval from the Dubai Electricity & Water Authority.

### Mitigating Urban Heat Island Effects

Expos are renowned for their exceptional projects, but what lessons can be learned for everyday architecture and landscape design? Many cities are now making extensive efforts to green their spaces and counteract the urban heat island effect. The benefits of trees with dense foliage and spreading branches that provide ample

shade are evident. Additionally, proper watering during dry periods is essential to create cool spots in hot cities when micro-climatic improvements are most needed to ensure the well-being of citizens. However, the role of vegetation in building and open-space design is often underestimated, especially in increasingly dense urban environments. Nonetheless, outdoor spaces will play an increasingly significant role in the future.

Designing them sustainably and with people's well-being in mind should become a natural priority. Plants, as exemplified by the Singapore Pavilion, can make a substantial contribution to achieving this goal. In hot and arid climates, small urban parks could be designed to harness the sun and groundwater as resources, creating habitats where people can enjoy their time in pleasant surroundings. By doing so, the need for seeking refuge in artificially cooled buildings would be significantly reduced.

### Acknowledgments

Client: URA, Singapore

General contractor: Radius, Singapore

Architects and concept of pavilion: WOHA, Singapore

Landscape Architects: Salad dressing, Singapore

Structure: WEB Structures, Singapore

Lighting designer: Light Collab LLP, Singapore

Architects of record: Dawson Architects, Dubai

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