Implementing Thermal Re-regulation in the Public Domain

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Creeping tides of undiscerning heat appear, at first, to affect the have-nots more than those with the means to run refrigeration machines. Power lines sag, resistance increases, and the demand for electricity supersedes what the diminished grid can provide. The hum of condensing units subsides, and silence cuts through the heavy, hot air. Suddenly, we are united—united in crisis.

In Transsolar's practice, we focus on the experience of being human in this thermal and climatic world. KlimaEngineering takes the extensive boundary conditions of our earth to design and engineer our context in a sustainable and inspirational way. To do that, we look for context, cues, and considerations across the world and into the deep knowledge that has developed in unique climates, but first, we must start at the beginning.

Earth bore from a collapsing cloud of gas and dust that started to spin from the initial angular momentum—this resultant Coriolis effect causes high-pressure systems to form. Cool air sinks, and warm air rises. Sinking air caps and traps warm ground air. Greenhouse gases (GHG) in the atmosphere exacerbate the trapped warm air such that it becomes even hotter. Hot enough to break historical temperature records. Hot enough to cause anomalies. Hot enough to cause dangerous heat for prolonged times: heatwaves.

And yet we adapt.

The constructed environment is our attempt at creating an extension of our body when the natural environment fails to accommodate us. We create, through technology, the application of scientific knowledge for the practicality of human life, art, and craft—to change and manipulate the environment. *Thus, when we encounter hyperthermia, how do we respond?*

We *have been* responding through air, sun, diurnal changes, local materials, greenery, and human behavior. Societies and cultures developed their vernaculars shaped by generations of knowledge. Extensive precedents illustrate this, from the American screened-in sleeping porches, double roofs in Southern Africa, open Arabic courtyards, and small but tall skywells with water pools of southern and eastern Chinese vernacular—all purposed in varying ways throughout the globe to expand our natural cooling.

We respond contemporarily with the ubiquitous use of GHG-emitting air conditioning. From 2000 to 2022, global carbon emissions from cooling have nearly doubled. Projections indicate that by 2050, over 5.5 billion air conditioning units will be in operation worldwide [1]. An auto-immune response providing temporary cooling, mistakenly usurping vernacular knowledge in favor of an excessive high-energy, high-carbon solution.

To re-regulate the human domain, we must act with a new vernacular. A vernacular defined by integrative and expansive thinking, met through layered iterative design, focused on climate-specificity, locality, and the extended (human) body. With today's tools, how can we unite lessons of the past with the technologies of today?

In our practice, we take resilience as a deeply embedded function of low-tech, climate-responsive design. Within this philosophy, technology is not necessarily the machine but the application of knowledge and technical practice. Our first step is identifying which climate factors we can influence while studying past vernacular strategies—not for formal inspiration, but to understand their fundamental mechanisms. How can we harness these time-tested principles? To illustrate this, we present a dialogue of approaches from our practice that enhance comfort and mitigate heat in extreme climates.

Pockets of Refuge: Where, When, and How

In areas of extreme heat, Transsolar proposes *cool pockets* as a part of *cool networks*. Several typologies have been integrated into hot climate projects (ASHRAE climate zones 0 and 1 / Köppen-Geiger climate zones A and BWh). The concept focuses on the human body and the factors that can impact thermal exchange (i.e., air temperature, humidity, mean radiant temperature, wind/air speed, metabolic rate, clothing, thermal history, and individual characteristics of our bodies). The cool pocket network uses cool pockets to provide a gradient of comfort spread throughout a building, a neighborhood, or a city at specified intervals to provide accessible and extended comfort for its inhabitants, omitting superfluous, unproductive conditioning of the entire area.

In Bahrain, cool pockets can reduce temperatures significantly for daily comfort and refuge during heatwaves, like the one in 2024 that reached 47.1°C [2]. In Manama, where there are dense districts of residential and commercial businesses, cool pockets could utilize prevalent NW winds to ventilate the narrow streets. The realization of the cool pocket is flexible and tailored for its specific use, site, and climate, and ranges from being very similar to ancient vernaculars to integrating modern technology. A cool pocket by Shri Krishna Temple could provide comfort between the *souq* and Bab Al Bahrain bus stop by reducing the mean radiant temperature (MRT) with ground painted or repaved in a lighter color. A higher “tech” cool pocket might include an active radiant cooling canopy powered by photovoltaic panels that cool up to 7 K. It could be a small device that causes a cool sensation on sensory receptors in the body for immediate relief—a complimentary lemon ice pop from a corner shop.

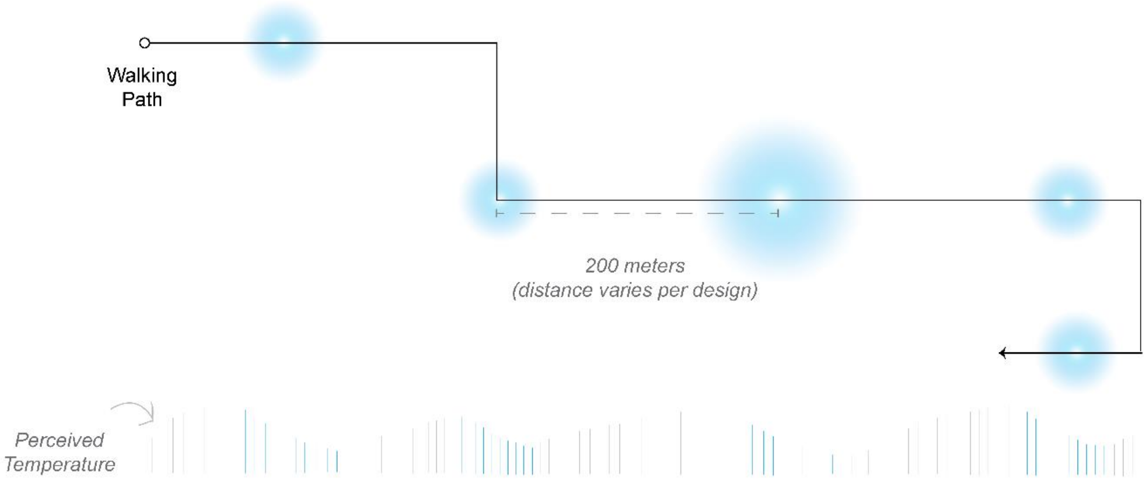

Figure 1 Diagrammatic representation of using cool pockets to create comfort

Transferring Vernacular in Changing Climates

As the climate shifts, the notion of adaptation has come to the forefront of our lexicon. The European heatwaves of 2003 brought a new awareness to the cities’ policies and planning in the wake of the crisis. Paris, a city with particularly low air conditioning adoption, recognized the need for urban-scale public intervention to reduce the heat and improve resilience for the future.

Transsolar's contributions to the redevelopment of Paris's Place de la République, completed in 2013, began nearly two decades ago in 2006 with our work on the Lycée Charles de Gaulle school in Damascus with Atelier Lion. In Damascus, the school campus exemplifies the translation of form, operation, and fundamental mechanisms of Syrian vernacular design into a contemporary and low-tech collection of interior and exterior spaces. The use of light-colored paving in the public plaza to reflect heat, courtyards, planting, and deployable shading all exemplify a master plan that is in direct reference to the intelligence of Damascene buildings.

The Place de la République, paved with dark tarmac achieved the opposite effect, accumulating heat from the day and releasing it at night. The redevelopment of the Place de République blanketed the streets, plaza, and promenades with high albedo pavers reminiscent of the Damascus school plaza bringing the intelligence of climate-responsive vernacular to a new locality.

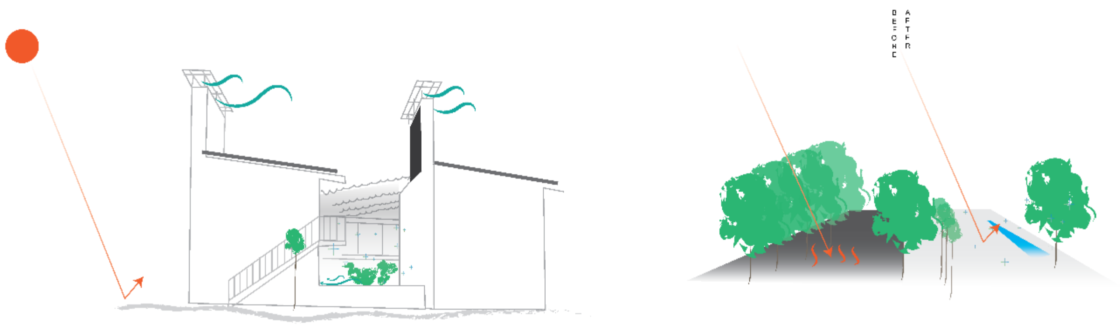

Figure 2 Diagram of the Lycée Charles de Gaulle school in Damascus, Syria (left), Place de Republique in Paris, France (right) Interventions

Detailed Models, Simple Mechanisms

Lee Kuan Yew famously opined that one of the most important factors in the success of Singapore in the late 20th and early 21st centuries was the air conditioner. This anecdote highlights the case of topical Singapore, where escaping the swelter could be attributed to its post-colonial societal vigor. It is also why Singapore has become a center for thinking critically about thermal comfort and creatively about mitigating heat stress. Traditionally, mitigating tropical heat was done by using deep overhangs to protect from the intensity of an equatorial sky and strong cross ventilation to elevate air speed to improve the effectiveness of sweating. The elevated Kampong houses, for example, not only avoid flooding and insect intrusion but also encourage ventilation beneath the structure and through the floor to increase comfort. Today, as a matter of efficiency and economics, most contemporary buildings define two distinct climates—an interior and an exterior.

This climatic paradigm of such focus on controlling the interior climate in Singapore, and indeed much of the world, triggers a unique opportunity to intervene in the public realm. A unique example of this from Transsolar's work is at the Mandai Zoo. Transsolar's installation used an approach that coupled detailed human-biometeorological models and a specific application of misting and elevating air speed to enhance comfort, quantified through the Universal Thermal Comfort Index (UTCI). The project first modeled, then designed, and finally validated the impact of special "dry mist fans," which use high-pressure nozzles to aerosolize water and adiabatically cool the air. The cool breeze provides a reprieve along one of the shady forested paths during a hot day visiting the zoo. In one of our most recent projects in Singapore—Pan Pacific Orchard, recently opened in 2023—the same dry mist mechanism was used in mid-door and outdoor spaces in the building by using both adiabatically cooled exhaust air from the conditioned ballroom and dry mist fans. Perhaps most notable is not the mechanism itself but the technical application of knowledge that expands and supports the public realm into something of a new kind of space that is resilient, low-tech, and deferential to the histories and vernaculars of the place.

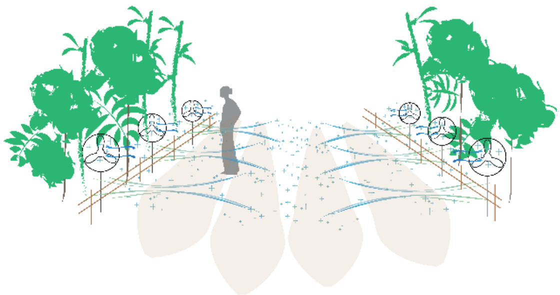

Figure 3 Diagram of the Dry Mist Path in Mandai Zoo, Singapore

Compound Machine as Extension of Teachings of the Vernacular

Throughout the design of several projects in desert climates, Transsolar has contributed to what we understand as the emergence of new vernaculars. In the arid desert, complementary passive and low-energy strategies build out a new vernacular. The possibility of high-yield renewable electricity from photovoltaics and solar thermal energy led to the exploration of new possibilities for responding to the sun, water, and night sky cooling. To provide cool comfort, we translate the sun, sparse rain, and night sky cooling into a self-sustaining all-electric cooling system supplied via rooftop photovoltaic thermal panels (PVT) with rainwater collection. The system harkens to ancient night-sky cooling techniques, where the clear desert night sky with its low temperatures and radiative exchange into the cold atmosphere can be used to cool down surfaces like stone seating with embedded tubing carrying 20-23°C sky-cooled water to provide cooling to people directly.

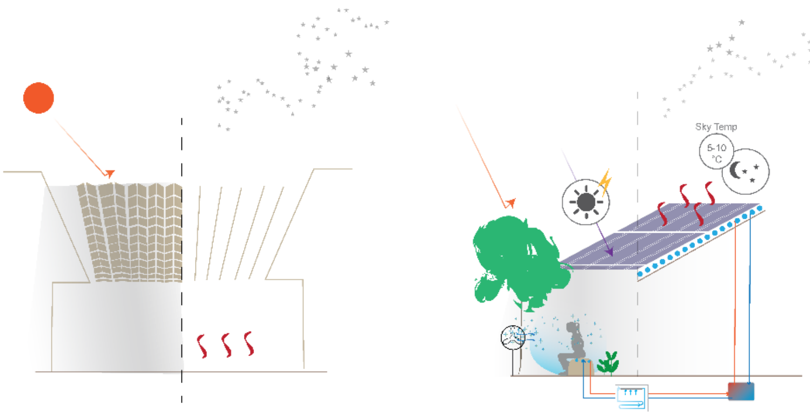

Figure 4 Diagram of Interventions in Desert Climate. Diagram of the passive night sky cooling with retractable shades in Al-Nouq Square, Doha (left). Diagram of PVT night sky cooling (right)

In projects of tropical deserts, the implementation of evaporative cooling and elevated air speed is highly beneficial because it drives the body to release more heat with the resources available. In extremely hot and humid climates, the body's thermoregulation (through sweating) is capped as it meets ambient humidity levels, but airflow and evaporative cooling over the skin alters the microclimate around the person, increasing its capacity again to thermally regulate. Deserts naturally have high wind velocities with prevailing wind directions, and in humid deserts, even hot winds have cooling benefits. Growing technologies like reusing AC condensate from buildings, redirecting spill air from buildings into used outdoor spaces, fog collectors, and hydropanels are defining—and redefining—new local practices that not only provide cool comfort but reduce extreme heat risk with available resources.

Climate Responsiveness Creates Lasting Identity

Within the discussion of our experience implementing design solutions to improve the regulation of extreme thermal conditions across the world, perhaps one of the most exciting opportunities lies in the cultural implications of defining a new vernacular. While the response to increasingly severe heatwaves has often relied on strengthening the divide between interior and exterior spaces—consuming large quantities of energy and limiting resilience in the process—there is a clear opportunity to harness the power of design while eroding a trend towards individualism. As such, through thoughtfully implemented technology and design, the public realm has the potential to vigorously affect the mechanisms that we experience not just in everyday life but also in how we collectively regulate and experience the thermal crises of today and the future.

References:

[1] Hannah Ritchie (2024) - "Air conditioning causes around 3% of greenhouse gas emissions. How will this change in the future?" Published online at OurWorldinData.org.

[2] *Monthly Weather Summary – July 2024*. Meteorological Directorate Climate Section. Ministry of Transportation and Telecommunications, Kingdom of Bahrain.

Biographies:

Jonathon Brearley is currently an associate at Transsolar KlimaEngineering, working on climate and sustainability engineering with a diverse range of architects and clients around the world.

Viola Zhang is a project engineer at Transsolar KlimaEngineering, coalescing her studies and experience in biological engineering, materials science, and architectural research to push forward passive solutions and elegant materiality to increase livability at the human, and urban level. She works in cross-disciplinary fields to develop and fabricate technology for more sustainable practice and environmental adaptability. Further interests and endeavors lie in biologically integrated research, living and vernacular architecture, biomaterials, and biodiversity conservation.