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Roesler, Sascha; Accademia di architettura, Università della Svizzera italiana, Svizzera
Kobi, Madlen; Accademia di architettura, Università della Svizzera italiana, Svizzera

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Microclimates and the City

Towards an Architectural Theory of Thermal Diversity

Sascha Roesler and Madlen Kobi

The term "microclimate" was coined by German and British meteorologists and geographers in the first half of the 20th century. Geiger[1] and Kratzer[2] realized that the climate in the air layer "two meters above the ground" differs considerably between rural and urban sites. Balchin and Pye[3] proved that the urban climate within one city, Bath, was not homogenous, but rather, comprised a variety of microclimates. Manley[4] distinguished three fundamental subjects of an urban microclimatology with comprehensive implications for architecture and landscape architecture: the microclimate of the plant cover, the microclimate of the topography and the microclimate of buildings. As interacting parameters, plant cover, topography and buildings shape the microclimates of cities, both in- and outside their buildings. Scientific research in the 20th century has thoroughly engaged with microclimates in their thermodynamic profiles; among other parameters, temperature and humidity became central to how microclimates are measured and defined. By setting up a reciprocal relationship between climate and architecture, between weather and human activities, city climate research both undermined and transformed the mono-causal approach of bio-climatic architecture. Urban climate phenomena such as heat islands or air pollution are strongly related to, and sometimes even intensified by, the built environment and its technologies.

The Architecture of the City—and its Microclimates

This publication aims at expanding these existing approaches from natural sciences and building science by emphasizing the man-made character of urban microclimates. We depart from the idea that "it is no longer viable to think of climate as a subject of climate science only,"[5] and conceive of microclimates, instead, as the result of, and unfolding within, human activities. Thus, the crucial task of today's microclimate research consists of understanding and describing the man-made materiality of the microclimate as human artifact, even though it appears to be a natural, nonmaterial and physical phenomenon. Urban microclimatology will remain an applied science without application (that is, without relevance to architecture) as long as local climatic conditions are not attributed to their architectural origins. Sitting on comfortably cooled park benches in subtropical Taichung, staying outdoors in a street café in Christchurch despite the cold sea wind, or strolling back and forth between radiant-heated indoor and outdoor terraces in Palm Springs are all examples of locally-created microclimates that are achieved through the purposeful design of spaces and the installation of technical appliances. As the microclimatic conditions of cities are more and more an outcome of their architecture and landscape architecture, a methodology is needed that re-interprets the plans, vedute and photographs, as highlighted, for instance, in Steen Eiler Rasmussen's *Towns and Buildings*[6] and Aldo Rossi's *Architecture of the City*,[7] for their microclimatic implications.

With a theoretical approach mediating between architecture and the social sciences, this publication explores how urban microclimates—outdoors *and* indoors—are a product of human engagements with the built environment of cities. In emphasizing the man-made nature of microclimates, we are inspired by Lisa Heschong's publication, *Thermal Delight in Architecture*,[8] which focuses on the social functions and gathering power of "thermal places." Both consciously and unconsciously, human beings create a diversity of thermal places. Heschong's collected examples—from the bathtubs in Japan to the Mediterranean plaza—underscore thermal places being closely linked to the daily activities of local community and family life. Heschong outlines that the creation of microclimates is not about implementing a norm in a closed and controlled space, but rather, that creating thermal comfort depends on the situations and needs of the people involved. Variability enhances the thermal quality of a place: "One factor that can help us to appreciate the thermal function of a place or object is variability. We are more likely to notice the function of something if there are times when it is not in operation, to notice the significance of something's presence if there are times when it is not there."[9] As natural or technical phenomena, microclimates are thermal zones with site-specific physical and thermodynamic characteristics. They are affected by temperatures, moisture, rain, wind, fog, snow, insolation, cloudiness, air quality and other factors.[10] As man-made artifacts however, microclimates are fabricated "thermal places" with various cultural, social and political meanings. In this publication, we consider microclimates to be a culturally and socially-shaped category, with architecture, landscape architecture and urban planning as beacons signaling the way.

The publication is a follow-up to the symposium, "The Urban Microclimate as Artifact," and the seminar, "Microclimate Ethnography," which both took place in the fall semester 2016 at the Academy of Architecture in Mendrisio (Switzerland) (Figs. 1 and 2). The case studies herein provide a cross-cultural and cross-disciplinary view on the phenomenon of urban microclimates. They deal with the design of microclimates in different climatic contexts and different seasons of the year. From XL to S, the chapters are arranged according to the physical sizes of their main spatial focus: territories (Heschong, Leggero), cities (Sahakian, Tavares), districts (Rahm, Kéré) and buildings (Requena-Ruiz, Brunner). Architect Lisa Heschong reports on the emergence of the notion of microclimate in the 1970s (USA); architectural historian Roberto Leggero highlights microclimatic patterns in Medieval cities (in northern Italy); sociologist Marlyne Sahakian addresses class-dependent forms of access to microclimates in Metro Manila (The Philippines); landscape architect Silvia Tavares highlights the use of public microclimates in post-earthquake Christchurch (New Zealand); architect Philippe Rahm presents the thermal diversity within the Jade Eco Park in Taichung (Taiwan); architect Francis Kéré explains passive strategies applied in the *Lycée Schorge* in Koudougou (Burkina Faso); architectural historian Ignacio Requena-Ruiz presents the mixed-mode use of active and passive climatization strategies in the *Maison de Brésil*, built by the atelier Le Corbusier in Paris (France); and architectural historian Matthias Brunner addresses the architectural and technical preconditions for a modern radiant-heated lifestyle indoors and outdoors, exemplified by the Richard Neutra-designed *Kaufmann Desert House* in Palm Springs (USA).

Although the size of the addressed subjects in this publication clearly changes with each chapter, only the (multi-)"scalar imagination"[11] of the contributions provides an adequate access to microclimates. In all the chapters, microclimates are embedded in a scalar dynamic that transforms our understanding of physical context, and transcends the conventional divide into inside and outside areas. This epistemological shift (identifying microclimates not only as outdoor phenomena) is manifested in the mutual reactions between the urban climate, the built fabric of cities and the artificial control of climate within buildings.[12] Urban microclimates can only be adequately understood as elements of a mutually-interacting network of buildings and exterior spaces, one created through linkages between indoor and outdoor climates that are too often separated into architecture (indoors) and climatology (outdoors). We are convinced that in order to approach urban microclimates adequately, we must understand microclimates as being embedded in larger urban and territorial settings. Thus, the case studies emphasize the linkages among projects of different scales—from the single house to the larger urban and territorial context. The thermal properties of a single apartment room in Manila, for instance, are related to the air-conditioned environment of large shopping malls inasmuch as residents move between these spaces.

This anthology joins together case studies that consider thermal diversity within the analyzed settings, not only between climate zones. The diversity of microclimates is created within complex place-making practices where local construction, architectural knowledge and globally-shifting standards meet one another. All of the case studies demonstrate that microclimates are closely related to architecture, infrastructure and material culture at large. Through objects, technologies and buildings, coping with microclimates is materialized and visualized through a "system of thermal-material culture."[13] A wide variety of actors is engaged in the creation of microclimates. As will be elaborated, thermal comfort has often been assigned to architects and HVAC engineers (heating, ventilation, air conditioning), but it is clear that residents, plumbers, trade-people and policy makers also intervene to transform the built environment with regard to climate-related aspects.[14] The case studies highlight that microclimates are far more than physical-thermodynamic phenomena, offering manifold valuable insights into everyday culture, social conditions and political aspirations of energy-based and urbanized societies.[15]

It seems that to live a modern urban life, one has to be independent of weather,[16] an assumption that led to the promotion of a homogenous indoor climate.[17] Laboratory experiments, as well as pressure from the industry, set indoor thermal comfort at a temperature between 20°C and 22°C with 50% humidity, and a whole industry has evolved from the associated notions and technologies of this "mass-commodification of comfort."[18] It is in the interaction of objects and technologies that indoor microclimates are created: "In technical terms, indoor climates are outcomes of dynamic processes of heat transfer through and between air, people, furniture, fans, heaters, walls, objects, etc. and the components and molecules of which these are made."[19] Considering the different actors, scales and contexts, this publication challenges the standardized definition of thermal comfort which has dominated for far too long. The cases presented in this book, which span locations from Paris to Taichung, from Manila to Milan, underline the cross-cultural and historical variety of urban micro-

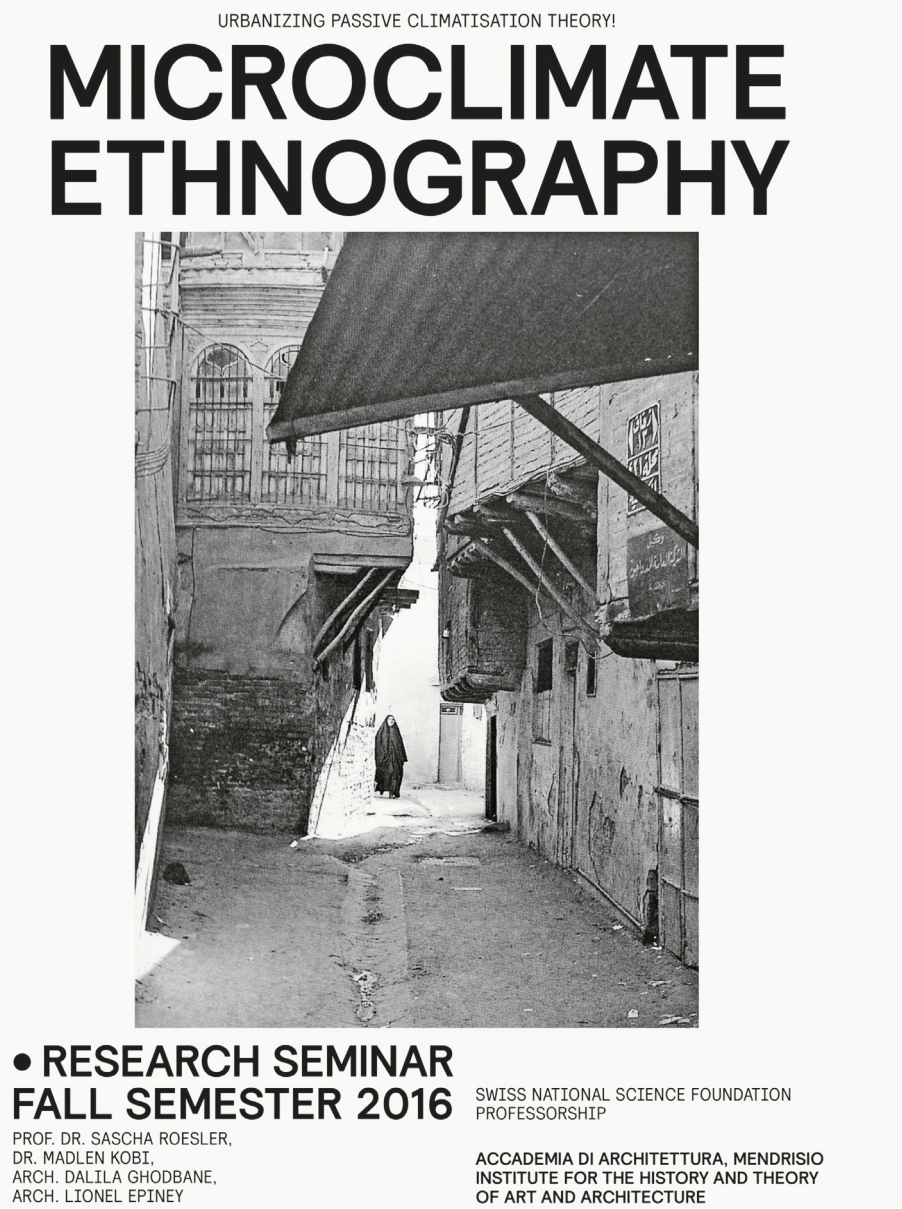

Fig. 1 Poster of the research seminar "Urbanizing Passive Climatization Theory! Microclimate Ethnography," fall semester 2016, Academy of Architecture in Mendrisio (Università della Svizzera Italiana).

climates. Beyond any moral attitude, this publication provides manifold historical and empirical insights into hybrid mixed-mode uses of active and passive climate control. In the 21st century, active and passive means of climate control are increasingly superimposed on one another, albeit unintentionally.[20] The contributions outline that while passive climate control is rarely used alone in the construction of contemporary urban microclimates, active cooling and heating clearly intervene in the production of microclimates, especially in residential spaces.

To look at the existing literature on microclimates (conceived as man-made artifacts), one gets the impression that this is still a purely scientific and technical subject, which has little to do with architecture, landscape architecture or material culture in general. A large number of publications has been devoted to the subject without, however, taking into account that more and more, microclimates are man-made and architecture-driven phenomena. Such publications and articles with a technical and practical approach to microclimatic design emphasize how wind channels, shadow areas or open squares produce urban microclimates.[21] The publication in hand, however, aims to complement the architecture and design perspective that is lacking in those publications, and to do so by emphasizing the relevance of microclimatic considerations for the work of planners and architects. The still outstanding transfer from basic meteorological research to architectural application has already been examined from a historical perspective: the anthology *City Weathers* by Hebbert, Jankovic and Webb (2011)[22] discusses the (failed) application of climatology in urbanism in different geographical and historical contexts. Remarkably, the theoretical and epistemological challenges emerging from the increasingly man-made character of microclimates, as discussed above, have been widely ignored by architectural theorists and social scientists to date, with only a few exceptions. In the anthology *Environmental Diversity in Architecture* by Steemers and Steane (2004),[23] climate control and comfort (among other environmental aspects) are scrutinized from an urban perspective. From an ethnographic perspective, Van Leeuwen[24] analyzed the symbolic interpretation of the air-conditioning system in Jakarta. In the 1990s, having an air-conditioning system or being surrounded by it (in the mall, for example) became a way of obtaining *gengsi* (prestige). Being close to *gengsi* means being close to the center of power. The air conditioning system in Jakarta is also linked to the power relations of colonial times. Climate in contemporary societies is central in the anthologies by Strauss and Orlove (*Weather, Climate, Culture*, 2003)[25] as well as Jankovic and Barboza (*Weather, Local Knowledge and Everyday Life. Issues in Integrated Climate Studies*, 2009)[26] which complement individual studies on particular sites.[27] From the perspective of an urban political ecology,[28] urban microclimates—as energy-consuming activities—have hidden environmental costs on the land and livelihoods of people living in the resource-extraction places outside urban areas.[29] In the case of other environmental consequences, such as air pollution, urban residents feel the health impact from electricity-producing factory pollution directly. All these contributions show the variety of approaches towards the mitigation of climate through time and space, but often omit the architecture and landscape architecture so central to the design and production of urban microclimates.

In this publication, the interviewed architects present various approaches towards the construction of microclimates: while Heschong and Kéré emphasize their interest in finding solutions that mitigate climate conditions through passive climate control, Rahm experiments with a variety of technical devices. He combines passive and active means of climate control in the Jade Eco Park in Taichung. All three architects use their own internationally-acquired expertise, but their designs also reflect local knowledge. Kéré, for example, who grew up in the area of *Lycée Schorge*, benefits from his own personal history when exploring ways to cope with the arid climate through

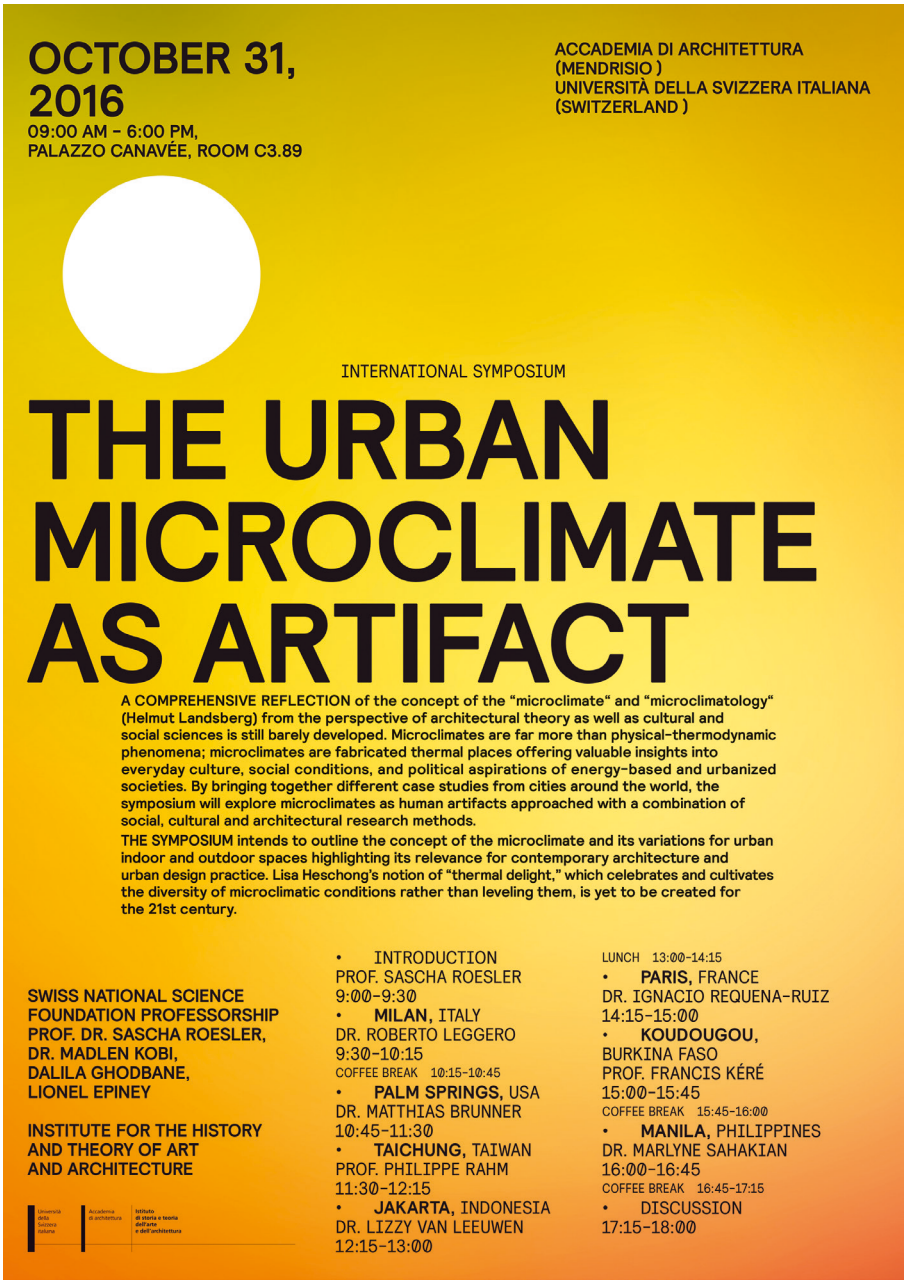

Fig. 2 Poster of the international symposium "The Urban Microclimate as Artifact" which took place on October 31, 2016, at the Academy of Architecture in Mendrisio (Università della Svizzera Italiana).

architecture. Although their architectural projects unfold in local places, the architects' ideas and designs result from constant exchanges with colleagues and experts all over the world. The microclimates presented in this volume are created through passive and active climate control means and related to mutual relations between indoors and outdoors, to the quality of life of urban residents and to city climates. Tying

in with the recent declaration that we live in the Anthropocene,[30] the case studies refer to the man-made character behind supposedly "natural" conditions. By recognizing urban microclimates as artifacts, the contributions remind us of three basic strategies of negotiating and constructing thermal diversity, each one relying on the skills of architects and landscape architects: 1. the agency of the body; 2. the provision of quality of life; and 3. the (re)connection of the inside and outside.

The Agency of the Body

Any research on microclimates must start by questioning the "nonmateriality" of microclimates by identifying their material aspects, without, however, succumbing once again to the primacy of the visual. In architecture, materiality is typically equated with visuality; an equalization that leads up the wrong path, however, since microclimates engage our other senses, too. "It is not enough to *see* architecture; you must experience it," as the architectural theorist Steen Eiler Rasmussen proclaimed.[31] Anthropologist Daniel Miller emphasizes invisibility as "this somewhat unexpected capacity of objects to fade out of focus and remain peripheral to our vision and yet determinant of our behavior and identity."[32] The central role of the body for the cognizance and design of microclimates is highlighted in all the contributions. The reinterpretation of the climate's materiality, as this publication promotes, builds on the agency of the body, mediating between the old dualism of climate and architecture. Thermal perception, rationalized away by comfort research, reappears prominently in Heschong's notion of "thermal delight," for example. The radical materialism of Rahm, unintentionally mirroring the body-centered, feminist attitude of Heschong, interprets microclimates as physical and chemical entities always in close relation to the body's physiology. His straightforward biological and chemical thinking extracts surprising architectural results from climatology and meteorology alike.

In the case of Jade Eco Park, thermal perception opens up a completely new field of experiencing microclimatic conditions. Rahm relies entirely on physiology, while Tavares refers to the metonymical game of meaning. Tavares addresses the "physiology and thermal perception" as linked to "the cultural context." Microclimates are associated, as Tavares shows, to other aspects of the environment: plant growing, farming and animals, for example. The often-emphasized importance of a close connection between town and countryside, and the perception of being "outdoors people" unites Christchurch residents of all social classes. The perception of microclimates is ultimately affected by prevailing fields of meaning.

Requena-Ruiz, in the case study of the House of Brazil, also discusses thermodynamic regulation in modern architecture. Among other citations, he refers to the thermo-regulating ideas of André Missenard, who suggested that the difference between outside and inside should not exceed 7°C to 8°C. Instead of decoupling indoor spaces from the climatic conditions outside, a mutual dependency enables a stimulating and healthy thermal diversity for the human body. The body, and its average normal temperature of around 37°C, serves both as starting point and receiving entity of all thermal interventions. The body not only reacts to the outside, but is itself a warming machine whose body temperature is used for forms of passive climate control.

Clothing, as a way of protecting the body, was done consciously to create intimate microclimates in medieval Italy (Leggero), and it remains a high priority in those cit-

ies even today (Sahakian). Leggero's historical case study focuses primarily on passive climate control in medieval northern Italian cities, where, in summer, its various measures included periurban gardens, passageways under the arches, wine cellars and the house itself as offering shelter from the outside weather conditions. In winter, different layers of clothing and the fireplace mitigated the cold. Leggero's contribution clearly demonstrates that the medieval towns of Europe share an intangible heritage, one which, to date, has not been sufficiently explored.

The buildings and public spaces of northern Italian cities have always had certain thermal implications for their residents. Yet since microclimates have both tangible and intangible aspects, they must be examined on many different levels. They are tangible as physical objects, whether buildings, parks, heating systems or the thermal infrastructures involved in generating them; and they are intangible inasmuch as people and groups—the way they behave, their institutions and their political directives—are involved. Microclimates are manifest in a constant interplay between visible and invisible materialities. Aspects of invisibility constitute, for example, the main quality of microclimate production, such as in the Kaufmann House in Palm Springs (Brunner) or in the rooms of the House of Brazil in Paris (Requena-Ruiz) where centrally-controlled, radiant underfloor tube systems both heat and cool the rooms. Although the inhabitants of these apartments know that materials and technologies are involved in regulating the microclimate of their residences, they forget their presence as the underfloor infrastructure remains invisible. As long as the central heating and cooling is functional, we are inclined to forget about the materials and technologies behind the creation of such microclimates.

The Provision of Quality of Life

Contradictions and conflicts around sustainability, economic development and social justice are mounting issues in residential urban life.[33] While urbanization improved living conditions for many, rising individual wealth has also increased per-capita carbon emissions. Air pollution is among the greatest challenges for mega cities today, given its severe impact on inhabitants' everyday lives and health. Mechanical indoor climate control creates "sealed" homes for the affluent and for select institutions in urban areas. Where electricity prices are high, air-conditioning to mitigate heat is inaccessible to some parts of the population. While people of different social status breathe the same outdoor air, economically disadvantaged groups cannot afford to move in such de-polluted indoor spaces and therefore suffer disproportionately more from air pollution's effects.

The affordability of technical devices that give access to different indoor microclimates also makes social differences more pronounced. Especially in cities in the global south, being able to afford an air-conditioning system or cooling fan is associated with higher status. The device itself becomes an ornamental object, much like a valuable piece of furniture that is proudly displayed to visitors. While it may not necessarily be in service all the time, alone the ownership of such air-conditioning devices raises prestige. The status gained from "exhibiting" the technology can be even more important than the actual effect the device has on creating microclimates.[34]

Sahakian's insights into cooling practices in Metro Manila highlight the way status shapes social practices: the affluent adhere to Western-style seasonal clothing—

Fig. 3 Poster of the international symposium "Thermal Standards in Architecture. Reflecting on the Globalisation of Passive Climate Control" which took place on October 30/31, 2017, at the Academy of Architecture in Mendrisio (Università della Svizzera Italiana).

only possible given the cooled microclimates in which they live. In the interview in this volume, Kéré emphasizes that it should actually be the other way around; for him, passive means of climate control are the true luxury, not the mechanical air-conditioning systems that make one dependent on electricity. In an economically poor context such as Burkina Faso, Kéré explores traditional thermal knowledge and local ma-

terials for creating cool spaces in a contemporary school building. Through his work, he underscores a democratic access to microclimate production even though social class and status still too often decide about available climate mitigation strategies. Even in the socio-economically less stratified regions of medieval Northern Italy, we learn from Leggero that while differences between districts were less pronounced, the poor population sojourned in other microclimatic environments. Dresses, for example, were made out of different materials for different social classes. What's more, the price of fuel determined the ways citizens could or could not improve thermal living standards in winter.

When it comes to contemporary outdoor microclimates, we find aspects of both exclusivity and of democracy. We might speak of the class character of urban outdoor microclimates by correlating the social class of a district and its quality of life, especially in emerging economies. People belonging to more affluent social classes often live in areas where more investment is made in creating favorable outdoor microclimates, e.g. through greening projects. In less stratified social contexts, democratic access to comfortable spaces seems to be characteristic of outdoor microclimates. In Christchurch, Tavares documents many residents' desire to spend time in pleasant places that feature a benign microclimate: wind-sheltered cafés or green spaces, for example. Her case study on public urban microclimates in Christchurch highlights the relevance of the built environment as a passive structure that creates comfortable spaces. All social classes use greening and vegetable gardens for microclimatic regulation. While indoor microclimates in mega-cities today depend increasingly on mechanical cooling or heating systems, the production of public microclimates still relies largely on the alignment of houses, the available green spaces or the provision of shadow spaces. Even if urban residents today spend more time indoors than outdoors, a city can actively encourage the creation of public microclimates for urban residents who enjoy being outdoors.

The (Re)-Connection of Inside and Outside

By focusing on the stabilization of thermal conditions inside of buildings, comfort research in the 20th century tended to neglect the empirical reality of interacting thermal zones. Insulating walls and sealing indoor spaces for more effective climate control became standard, leading to the idea that people live in "encapsulated" or "isolated" worlds.[35] However, contemporary cities are shaped by mutual reactions between inside and outside, anticipating an incremental, rather than bipolar connection between interior and exterior spaces. In order to achieve better results in creating comfortable microclimates, and also to enhance energy efficiency, "design strategies must reassert the links between the indoor and outdoor as part of a broader engagement with the urban climate."[36]

Among the case studies presented, the most obvious example of the reconnection of inside and outside is the case study of the Kaufmann Desert House, whose terrace becomes a semi-outdoor space through the radiant heating system hidden in the floor. As Brunner outlines, outdoor air was considered healthy and indoor air harmful in the first half of the 20th century. These premises influenced Richard Neutra to promote ventilation in his architecture as an element that contributes to comfort. In winter, residents could comfortably breathe the fresh outside air while, at the same time,

being warmed from below. Brunner emphasizes that through this construction, the Kaufmann house has no clear climatic and physical/material borders, but that the indoors extends to the outside of the architectural structure that usually delimits it. The outside only begins where the terrace ends, not with the terrace door. For Neutra, the reconnection between indoors and outdoors was the most important aspect guiding his architectural designs. Although energy costs and environmental concerns were of lesser significance, the Kaufmann Desert House may serve as an inspiring example for combining indoor and outdoor spaces from a design, aesthetic and atmospheric perspective.

Manipulating the outdoors is also possible through humidifying devices, as in the case of the Jade Eco Park. Rahm introduces a series of aesthetic cooling devices that provide unseen microclimate control: the large mushroom-like objects, artistic tubes and oversized umbrellas of the Jade Eco Park in Taichung almost seem to have come from outer space. The indoors have already been managed by microclimate devices for several decades, but there is still potential for new technological innovations for the creation of outdoor microclimates. In addition to the cooling and purifying effects of park greening, geothermal energy is used to run the dehumidifying and depolluting devices.

In sharp contrast to these technology-driven solutions, Kéré explains how, at the *Lycée Schorge*, it was essential for him to implement buffer zones between the outside and the inside to mitigate the winds, and to create shaded spaces where school children can play or eat. Such buffer zones not only create social interaction zones, they are also useful for the thermal insulation of buildings. A famous example of buffer zones is Lacaton and Vasall's addition of winter gardens to the outside façade of Bois-le-Prêtre, an outdated apartment building in Paris. Instead of demolishing and rebuilding the entire house, these buffer zones were added to improve the insulation of the building. At the same time, they increased the living space of the apartments and opened up the view.

While the spread of 20th-century building services has established a strictly complementary relationship between indoor and outdoor areas, the connection between interior and exterior in passively controlled urban settings is incremental. The interior (indoor climate) remains connected with the exterior (outdoor climate). In contrast to the modern bipolar thermal concept, which keeps the indoor climate constant at all costs, passively-controlled urban settings are marked by numerous superimposed thermal zones and layered microclimates. A livable environment with thermal diversity offers overlapping and interacting thermal places. Rather than being simple meteorological phenomena, microclimates are the result of human interventions in the environment. It is under these premises that this anthology investigates the urban microclimate as artifact in different cultural, economic, political and social settings around the globe.

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