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Thermal modernity and architecture

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This paper develops the concept of thermal modernity in order to offer a more detailed understanding of air conditioning and the historical role it has played in transforming urban and built space. An analysis oriented by the insights of Science and Technology Studies stresses how the international ascendency of air conditioning has been contingent upon certain socio-political forces and cultural changes that occur at the local level. The productive example of Singapore—often referred to as the ‘air-conditioned nation’—is given to reveal the entanglements between indoor comfort provision, economic development and post-colonial nation-building. At a broader level, the paper points towards the importance of understanding air conditioning’s impact on the spread of international modernism in analytically expansive ways, such that we can more fully appreciate how it has acted to remodel the built environment at different scales and reconfigure indoor and outdoor relationships.

Introduction
Thermal modernity is emerging as a new space of critical debate on the back of demands for more sustainable built environments. In those hotter parts of the world, most notably desert, tropical and sub-tropical regions, much of the twentieth century was about building cool, comfortable spaces, through increasingly sophisticated forms of mechanical air conditioning. The critical challenge thus lies in departing from this energy-intensive paradigm, and cultivating alternative thermal modernities that prioritise low-carbon design and social practice. While important work is now being done in this area, there is little doubt a thermal modernity oriented by air conditioning remains dominant, even hegemonic in the ways built space is perceived and inhabited. To understand better why and how this situation of dominance exists it is important to understand the historical trajectories through which an air-conditioned thermal modernity gained its ascendency. This paper takes up this task and does so by considering the ways in which mechanical air conditioning has served as an important force in physical and social change.

Within the growing debate around thermal modernity, texts tracing the advent and growing penetration of air conditioning over the course of the twentieth century have largely focused on the United States and, to a lesser degree, Western Europe. Authors have directed their attention to the broader histories of air conditioning, the socio-political dynamics that have advanced its growth.
across different forms of public and private space, and how comfort norms and practices have altered in dialogical ways. Undoubtedly highly instructive, these accounts have paid less attention to the ways in which air conditioning has acted as an agent of architectural transformation. Indeed, we would contend that the transformative complexities, both physical and social, of air conditioning remain poorly understood. Within the historiography of modernism and the international expansion of a built environment modernity, air conditioning has been primarily framed, even caricatured, as a universal technique and thus read in opposition to a prototypical localised rooted culture.

In line with the arguments of Oldfield, Trabucoo and Wood concerning the importance of properly historicising energy and architecture, this paper attempts to offer a more detailed understanding of air conditioning and the historical role it has played in transforming urban and built space. Accordingly, we approach air conditioning through the analytical lens of Science and Technology Studies (STS); a perspective that foregrounds ideas of how technologies mutate and transform as they circulate and cross boundaries. To help address the privileging of North America and, to a lesser extent, Europe in the annals of air conditioning, we focus on the experiences of Singapore.

The city-state of Singapore is analytically productive for four key reasons. First, it reveals how air conditioning and its adoption in urban environments is far from a universalising process, and is instead a process that takes on particular socio-cultural meanings in context, and assembles into different socio-technical and spatial systems across different locations. Second, by looking at a non-Western context, Singapore also helps us account for air conditioning’s role in the spread of international modernism in analytically expansive ways, allowing us to tease out themes such as how indoor/outdoor space comes to be imagined and encountered in new ways. Third, geographically speaking, then, the case of Singapore moves us beyond the now familiar accounts of air conditioning in Europe and North America, to a more critical understanding of its global relevance. Finally, with Singapore popularly referred to as ‘the air conditioned nation’, the paper seeks to provide a more rigorous account of the role this technology has played in the city-state’s development and nation-building, particularly since Independence; an historical narrative that has, somewhat surprisingly, hitherto been overlooked by scholars. What the case of Singapore reveals particularly vividly, more so than we see in the experiences of the US or Europe, are the powerfully post-colonial socio-cultural meanings and political values—such as productivity and national development—that come to be invested in a technology such as air conditioning.

**Modernism, techno-science and mobilities**

Recent years have seen the emergence of exciting debates concerning the relationship between globalisation, the rise of modernism and the internationalisation of modernist architecture. Drawing on post-colonial theories, the focus of this literature has been insightfully cast on a number of themes that foreground the geopolitics and power of architecture omitted by the previous scholarship on the globalisation of architecture, such as critical regionalism.
These themes include colonialism and decolonisation, and cold-war politics and international development; analytical avenues that have led to various interesting claims and debates about modernism as a form of universalism under the conditions of global capitalism. We draw on these analytical avenues on the politics of architecture but we shift our attention to the socio-technical aspects of the globalisation of modernism, which has yet to be given sustained attention and critical account. In broad terms, the techno-scientific aspects of modernism rarely feature in the literature on modernism, and when they do the focus is either on Taylorism, efficiency and the functionalist aspects of building and planning, or on new industrial materials, innovative construction methods and the tectonics of building.

The environmental technologies connected to building services, such as the heating, cooling, ventilating and lighting technologies, are seldom discussed in what Reyner Banham sarcastically describes as the ‘narrow-eyed aesthetic vision’ of architects and architectural historians. In those few instances that environmental technologies are discussed, they tend to fall into two main types. The first type contains the few seminal accounts of technologically innovative buildings by renowned architects, and the geographical coverage concerns primarily North America and Europe. The second type of discussion concerns mainly the environmental technologies of an ordinary building outside North America and Europe. In this case, the discussion is frequently reduced to a caricature, based on what Reyner Banham describes as the ‘infantile fallacy’ that ‘the mechanical and cultural parts of the art [of architecture] are in essential opposition.’

One such example is Kenneth Frampton’s oft-quoted description of air conditioning: the main antagonist of rooted culture is the ubiquitous air-conditioner, applied at all times in all places, irrespective of the local climatic conditions which have a capacity to express the specific place and the seasonal variations of its climate. Whenever they occur, the fixed window and the air-conditioner are mutually indicative of domination by universal technique.  

In the quotation above, the air-conditioner is flattened into a symbol of the ‘domination by universal technique’ and associated with the type of global architecture that suppresses expression of place-based culture and is thus regarded as anti-regionalist. While we appreciate Frampton’s point of view and respect this architectural tradition, we find the binary oppositions between the local and the global, rooted culture and universal technique, place and space as problematic and analytically restrictive. We are particularly uncomfortable with Frampton’s dissociation of architecture from political circumstances, especially his neglect of the socio-cultural challenges which former colonies faced in decolonisation and post-colonial development that Mark Crinson has pointed out.

The international movement of air conditioning has also been encapsulated by notions of ‘technology transfer’, a narrative framing that has accounted for the cross-border, cross-continent movement of the techno-scientific aspects of architecture as a process involving little disruption or change. However, as various scholars working within the field of STS have cogently argued, technology...
transfer has remained a reductive concept that fails to capture the complexities of the circulation of technology in at least three critical ways. First, the diffusionist understanding of technology transfer ignores the social and cultural construction of technology. As David Nye and other historians of technology have noted, the social significance of technology is not technologically determined because the socio-cultural meanings of technology are malleable. When a technology is relocated from one site to another, its social significance and cultural meanings are likely to be transformed because people in a new socio-cultural context interact with the same technology differently and attribute different meanings to it. Extending this insight to the technology of air conditioning, this paper shows that, in the context of Singapore, mechanical cooling was inextricably linked to colonial ideas of climate and civilisation, and, consequently, deeply embedded in the culture of post-colonial developmentalism.

Secondly, when technology circulates to another locality, not only does it acquire new significance and meanings, similar technology might also be appropriated and used in distinctive ways. David Edgerton called such distinctive uses of technology that are ‘derived from, but different to, the originating case’ and thus contrast with metropolitan ways as ‘creole technologies’. He argued that these creole technologies were ignored by most global histories of technology because these histories tend to be innovation-centric, conflating technology with technological novelty and innovation. Edgerton argued for the need for studies of technology-in-use in order to understand the technological worlds that have emerged globally in the twentieth century. In our exploration of air-conditioning-in-use in Singapore, we argue that the scale, rate and pervasive manner in which air conditioning was deployed cause it to offer unique insights to understanding the technology.

Thirdly, STS scholars acknowledge that while technology is malleable, it is not indefinitely so. Technology exercises what Thomas Hughes calls ‘soft-determinism’ on society and culture. To understand how technology shapes society through soft determinism, it is important to see technology as not a thing in isolation but as part of a complex system that is deeply embedded in society. To that end, the paper traces how the complex system of air conditioning, architectural design, urban planning, constructional components, especially the building envelope components, thermal comfort and social practices come together in a mutually reinforcing manner between the 1930s and 1990s.

Colonial tropicality, climate control and the arrival of air conditioning in Singapore

To understand the take up of air conditioning in post-independence Singapore, it is useful briefly to discuss colonial discourse about climate and comfort in the tropics in general and about early air conditioning in late-colonial Singapore in particular. Many scholars have argued that climate and comfort are as much socio-technical or socio-cultural constructions as they are simply, for the former, a natural phenomenon or, for the latter, a physical state. For example, James Fleming and Vladimir Jankovic argue that ‘[c]limate is a discursive vehicle capable of naturalizing matters of social concern...
David Arnold and Felix Driver have also suggested that ‘the tropics’, where most of the British colonies were located, was positioned as the environmental alterity to the norm of the temperate climate. It was a landscape trope first constructed within the cultural-political nexus of empire: in part, through the nineteenth-century miasmatic theory of disease and transmission; a torrid zone detrimental to the health of the European inhabitants. When the miasmatic theory was discredited and replaced by germ theory in the early twentieth century, the tropics was in turn seen as unfavourable to the comfort and productivity of the European. The tropics was not merely an environmental alterity, it was also entwined with other socio-cultural alterities and seen as the zone that was backward and which lacked civilisation. The negative perception of and the attendant concerns with the heat and humidity of the tropics meant that the European colonists invested large amounts of intellectual and material resources to develop various urban planning strategies, architectural design principles and environmental technologies to ameliorate their own health and comfort.

When air conditioning was invented in the early twentieth century, Singapore awaited its arrival with much anticipation. Local newspapers were already reporting on the potential benefits of air conditioning even before the first system was installed. In 1929, for example, a lecture given in Hong Kong by C. A. Middleton-Smith, Taikoo Professor of Engineering, University of Hong Kong, was deemed newsworthy, with the author cited as stating that ‘the twentieth century… would be famous in history for the civilisation of the tropics’. Drawing on Ellsworth Huntington’s theory of climate and civilisation, he added ‘the struggle for survival of human life was fiercer here [in the tropics] than in the more temperate regions. Not only was the climate more enervating but all sorts of foes to human life abounded.’ He believed, however, that the introduction of air conditioning and its ‘manufactured weather’ would make the tropics more healthy and prosperous, transforming such regions from backwardness to civilisation.

In 1934, Kenneth Black, a Professor of Physiology at Singapore’s King Edward VII medical school, prophesied an imminent future wherein homes, offices, theatres and railways would all be air conditioned to keep the temperature around 70 degrees Fahrenheit ‘allowing everyone to sleep, work, travel and be amused in the best atmosphere’. But with the technologies of air conditioning (AC) yet to be installed in any public building, one newspaper lamented that Singapore was lagging ‘far behind’ other major cities in the tropics and residents were not able to enjoy an atmosphere in which ‘[t]en minutes … has a bracing effect that is unobtainable by other means in the tropics’.

Such debates and commentaries were indicative of the importance attached to cooling and thermal comfort in the tropical climate of Singapore. These debates and commentaries were also symptomatic of a growing desire to ‘advance’ beyond existing ways of maintaining bodily comfort. The anticipation and excitement surrounded the prospect of replacing electric fans and other older forms of environmental technologies like the punkah and thermantidote with more ‘active’ forms of cooling.
led to various experiments with other pre-AC cooling technologies. Many of these experiments used technologies that did not entail the two key features of air-conditioning—dehumidification and refrigeration. One such technology was the Solo Air System, a technology invented and patented by the Singapore-based British engineer E. H. Hindmarsh. With early installations including the General Post Office (Fullerton Building), Capitol Cinema and Supreme Court,18 Solo Air employed a simpler and cheaper mechanical ventilation system that filtered outside air and supplied moving ‘purified air’ to individual outlets embedded into furniture such as chairs, tables and cupboards.19

AC was finally introduced in Singapore in the late 1930s (Fig. 1). Its use was very limited, primarily restricted to spaces of consumption such as the cinema and the hotel in the pre-Second World War years and, in the years immediately after the war, to prestigious office buildings. The first buildings in Singapore that had AC installed were two of the city’s cinemas: the New Alhambra Theatre in 1938 and the Cathay Cinema (Fig. 2) in 1939. In the latter year an advertisement for the Cathay Cinema proclaimed that ‘The Cathay surely represents the final word in Modernity, Artistry and Efficiency. Here the Devotees of the Cinema Cult can revel in upholstered luxury, air cooled comfort and expert service …’ Similar marketing for the New Alhambra Cinema promoted a ‘mountain-air climate’, just like the hill stations.20 The association of luxury with comfort within a context of hospitality caused hotels soon to follow suit. Across colonial Southeast Asia, hotels were typically the first buildings to have electricity, offering electric fans and electric light, among other ‘modern conveniences’ to their guests.

By 1950, the Raffles Hotel, one of the region’s premier colonial hotels, advertised air-conditioned rooms. As a Raffles Hotel advertisement noted, better cooling technology made European social rituals such as gala dinners and balls more bearable.21 Over the following years more hotels promoted air-conditioned rooms and other ‘comfortable’ facilities, such as dining halls. Hospitality thus became an important medium through which air conditioning was semiotically loaded as a marker of modern consumer comfort. Indeed, both cinemas and hotels can be read as important entry points for an emergent consumer culture that commodified indoor climate.22 But what was a novelty in the 1930s to the 1950s, limited to a small segment of consumers, would eventually become an essential part of mass consumption, as we shall notice shortly.

Beyond such spaces, other early adopters were the early post-war office towers. The first building in Singapore to be fully air conditioned was MacDonald House (Fig. 3), a nine-storey office tower completed in 1949 to house the offices of the Hong Kong and Shanghai Bank. Unlike the cinemas and hotels from the 1930s and 1940s, where only some spaces were cooled, MacDonald House was completely air conditioned and was the first such building in Southeast Asia. It also happened to be the first building outside of the Western Hemisphere to be equipped with a Carrier Conduit Weathermaster System, the same technology employed by the United Nations building in New York.23 The installation of the latest mechanical cooling system at MacDonald House was complemented by the use of
Figure 1. Highland’s Atmosphere: a 1937 Advertisement for Carrier Portable Air Conditioners in Singapore (source: United Engineers).
luxurious finishes such as Roman travertine on the exterior and Filletto Rosso marble in the banking hall. The building was regarded by the local newspaper as setting the standard for post-war building in Singapore and hailed as ‘the forerunner of this city’s plan for rehabilitation as it turns towards the establishment of a new and more beautiful city’.24

Some years later, the Asia Insurance Building (Fig. 4), completed in 1955, was also fully air conditioned. At eighteen storeys high, it was the tallest landmark in the colony and probably South-east Asia when it officially opened in December that year. Financed by a local insurance company, owned by a Chinese businessman and designed by a prominent local Chinese architect, Ng Kheng Siang,25 the Asia Insurance Building was the most conspicuous symbol of Asian capital in Singapore at that time, and thus was christened ‘the colony’s skyscraper’. Just as with MacDonald House, its equivalent for European capital, the latest technologies were employed in the Asia Insurance Building and its exterior was lavishly adorned with expensive imported materials such as travertine and rare black Silician Nero Portoro marble. Unsurprisingly, the Asia Insurance Building was regarded by the Commissioner-General Malcolm MacDonald as ‘something more than a business house … a declaration of faith’ in the future of Singapore at a time of social, economic and political uncertainties because of decolonisation.26 Indeed, these two buildings, as
mechanically cooled exceptions in a landscape of largely naturally ventilated buildings, were more significant as lavish symbols of confidence in Singapore’s future than as symptomatic representations of the austere naturally ventilated ‘architecture of economy’—such as low-cost housing, schools and medical buildings—that were erected in the immediate post-war years.27

These early air-conditioned buildings bore little resemblance to those glazed curtain-wall towers that became the near ubiquitous symbols of post-war global capitalism. Both the Cathay Cinema and the Asia Insurance Building were designed in the architectural language of tropical Art Deco, with horizontal sun-shading fins projecting over windows. Unlike glazed curtain-wall towers, which easily overheat due to large expanses of unshaded glazing, both structures featured a higher proportion of solid surfaces and thus helped protect interior spaces from solar radiation and external ambient conditions. Not unlike modern tropical architecture, the shallow floor plan interiors of these buildings could be naturally illuminated and ventilated by means of operable windows. Indeed, such elements formed part of a wider understanding at that time of climate-responsive design in the tropics.28

Looking back at this period, what becomes apparent is that considerable debate and attention was given to the merits of utilising both ‘passive’ and ‘mechanical’ cooling techniques. Significant installation and operating costs meant that air-conditioning systems required justification. AC and its integration into the building system and society was yet to gain technological momentum and become normatively adopted in Singapore’s construction sector. Throughout the 1950s, considerable attention was still given to the use of sun-shading.29 Otto Koenigsberger, for example—one of the best-known architects and educators in modern tropical architecture—noted in a lecture to his students at the Architectural Association’s Department of Tropical Studies (DTS) that only a ‘privileged minority’ could afford air conditioning and it thus should not be considered as a
sufficiently economical means of providing thermal comfort for all.\textsuperscript{30}

Whilst a colonial discourse of tropicality continued to exert influence in the mid-twentieth century, it was also reconfigured to suit the larger context of decolonisation and post-war developmentalism. For example, the early twentieth-century environmental determinist theory of Huntington on climate and civilisation was modified by S. F. Markham’s environmental possibilist theory about climate control in the 1940s. Markham claimed that ‘one of the basic reasons for the rise of a nation in modern times is its control over climatic conditions’.\textsuperscript{31} As the theory became less determinist, the racist undertones also diminished as the indigenous people in the hot and humid tropics were no longer condemned to backwardness because of the climatic conditions.

Drawing from Markham’s theory, Koenigsberger, for example, proposed to his students at DTS that early civilisations took root in regions around 21 degrees Celsius (70 degrees Fahrenheit), but that with the invention of technologies or materials of heating—such as the fireplace, chimney, grate and coal—civilisations moved northwards towards colder regions. It was a narrative that provided the justification for climatic design. Accordingly, he argued, ‘the historical role of architecture [as the] controller of climatic environment … influences the fate of nations’,\textsuperscript{32} adding in a subsequent lecture ‘if this historical analysis is correct, it is time for architects to learn to master hot climates to restore the “balance of power”’.\textsuperscript{33} Instead of having the destiny of their nations being over-determined by hot tropical climates, people in the tropics could exercise agency and shape their own fate by mastering the control of their hot climates. This powerful idea would prove to be influential in post-Independence Singapore.

**Post-independence development and the new air-conditioned modernity**

Air-conditioning was a most important invention for us; perhaps one of the signal inventions of history. It changed the nature of civilisation by making development possible in the tropics. One forgets this, living in North America or Europe or northern Asia. Without air-conditioning, you can work well only in the cool early morning hours, or at dusk. The first thing I did upon becoming prime minister was to install air conditioners in buildings where the civil service worked. This was key to public efficiency.

Lee Kuan Yew\textsuperscript{34}

The quotation above, taken from an interview that Singapore’s first Prime Minister Lee Kuan Yew gave in 1999, illustrates the latent influence of colonial ideas on climate, development and civilisation. Equally, however, it also reveals the critical importance he placed on AC in the socio-economic development of the city-state after Independence.\textsuperscript{35} It was a perspective that would orient government policies towards embedding AC in the built environment over the coming decades. AC was installed in many of the offices of the newly formed Singapore civil service in the 1960s. The high cost of installation, building modification and operation during the 1960s caused AC to remain a privilege for those deemed most critical to the proper functioning of the state. Not surprisingly, those who benefited
first were senior civil servants, ministers, parliamentary secretaries and political secretaries, with junior civil servants having to make do with fans. According to records from the Finance Department dating to the late 1960s, more than $350,000 was allocated to the installation and maintenance of around 1,400 window-model units across various government departments.36

More profoundly, though, it was a discourse of governance concerning urban renewal, new urban typologies, that made air-conditioned comfort a central canon of post-independence socio-economic development. Singapore was characterised as a ‘developmental state’, one in which market and society were dominated by an interventionist state. Led by technocrats and advised by technical experts, the developmental state and its agencies used their socio-political power to organise society and direct capital so as to advance economic growth.37 The main strategy for economic growth in the post-Independence era was to transform the entrepôt economy into an industrial economy by attracting foreign investment from multi-national corporations.

An important aspect of urban renewal (figs 5, 6) was for the state to acquire shophouses—which were regarded as insanitary and overcrowded ‘slums’—clear them and consolidate the land that they occupied into extensive plots suitable for the construction of large modern office buildings to serve the industrial economy.38 The urban renewal process was facilitated by the passing of the Land Acquisition Act in 1966, which allowed the state compulsorily to acquire land at a low price. That in turn enabled the state to limit the cost of urban renewal, and execute the programme rapidly and extensively. The consolidated plots of land were sold in phases through the Government Land Sales programme from 1967. On these large tracts of land that subsequently made up a major proportion of the Central Business District, the old colonial shophouse typology, that housed the ‘slums’, and its urban fabric of narrow streets and backlanes,
were demolished and replaced with a new air-conditioned urban typology—the podium-tower typology—and its urban fabric of big urban plots, wide roads, large open spaces. Whilst the podium-tower was a familiar typology elsewhere, the scale and extent of the urban renewal programme, and its attendant socio-political ideology and cultural meanings, made Singapore a distinctive case. As Brenda Yeoh noted:

The transformation of the landscape, however, was not only perceived as a means of improving living conditions for the people but as both prerequisite for (and tangible proof of) larger forces of socio-economic development and progress at work in the State.39

Rem Koolhaas described this radical transformation and drastic erasure of the old colonial urban environment as the tabula rasa approach: ‘the razed plane as the basis for a genuinely new beginning’.40 Such a tabula rasa approach not only created a modern city, it also forged a new air-conditioned thermal modernity.

If the previous AC installations were restricted to a few isolated examples initiated and funded by
private capital, the new installations were much more systematic as they were implicitly mandated by the building types stipulated by the state planning agency, and frequently involved state agencies or state-linked entities. An exemplar of this trend was the twenty-two storey Ministry of National Development building (figs 7, 8). With the Ministry combining the state’s key housing, planning and building agencies, its headquarters would stand as a powerful icon of the state’s building and planning ideology. Designed by government architects at the Housing and Development Board, and occupying a site of almost three hectares, the building was declared Singapore’s ‘most modern Government building’ upon its opening in 1969.41

For the first time, all the departments of the ministry were consolidated within a single building, bringing about centralisation and greater efficiency of operation. Its design centred around a slab block that rested on a two-storey podium; one of the earliest built manifestations of a podium-tower typology that required mechanical forms of cooling. The slab block featured a relatively flat façade, and with a typical floor plate of the slab block spanning nearly twenty metres, cross ventilation was minimal. The architects claimed, ‘quite unlike the traditional image of government office, either locally or overseas, this building projects a clean façade as well an equally clean and shiny interior’.42 The building was fully air conditioned at great expense (1.8million Singapore dollars), with the installation of two centrifugal compressors capable of producing 400,000 cubic feet of cool air per minute.43 The air-conditioning technology was an inextricable part of spatialising and projecting the modern image of a centralised, efficient, clean and shiny new state, unshackled by the bounds of tradition.

This podium-tower typology also provided the design blueprint for another symbolically important structure which opened in the same year, the Malaysia-Singapore Airlines building. Designed by the local firm Architects Team 3, this building housing the headquarters of the national carrier was the first podium-tower type to be erected in Robinson Road.44 This time the three-storey podium was more clearly articulated, with a long and largely blank façade facing the adjacent road. Although the glass façades of the tower were protected by a layer of aluminium sun-breakers ‘specially designed to allow an unobstructed view from inside the building and still give maximum protection from sun’s rays’, this was also clearly an air-conditioned building.45 If the Ministry of National Development building exemplified the state’s approach to building, the Malaysia-Singapore Airlines building represented the model that prefigured the type of office building developments financed by and built for private capital in the neighbouring Shenton Way area, a large empty plot of land reclaimed from the sea that would witness rapid development in the 1970s. The concept of the podium distinguished these structures from the older air-conditioned buildings built in the 1940s and 1950s. Constructed on large consolidated plots of land, these podiums tend to cover large areas, often with few external windows. As a design form, such large windowless interiors were only possible through centralised air-conditioning. As Leong and Weiss note:
Only air conditioning can make windowless, sealed, interiorized, artificial environments so natural and so comfortable... mechanically engineered climates enabled an explosion of the depth of the interior, creating spaces increasingly divorced from the outside... As interior conditions are perfected, the outside becomes increasingly unnecessary. As a result, it is possible for the first time to imagine that the window – long assumed to be one of the most indispensable architectural elements – could become obsolete.46

The design of the towers also departed from the pioneering air-conditioned office towers of MacDonald House and the Asia Insurance Building in other ways. The plans of the new towers were deeper and the proportion of glazing on their façades was also greater. While there was some level of sun-shading on the Ministry of National Development building and the Malaysia-Singapore Airlines building, the
Figure 8. Section of the Ministry of National Development building (source: SIAJ: Journal of Singapore Institute of Architects, 1972).
towers that were completed subsequently had less and less sun-shading. No longer designed to be naturally illuminated and ventilated, the design of these towers was moving towards the global model of the hermetically sealed curtain-wall office towers. As one engineer noted, ‘Air conditioning in this building (type) is so fundamental to the design that the building could not operate without it.’

The only concessions to the hot and humid tropical climate in these subsequent office towers were dark tinted panes and venetian blinds designed to reduce solar heat gain.

The design of these buildings might be similar in form to the air-conditioned office towers in other parts of the world but the socio-political context in which they were erected and the socio-cultural meanings they had engendered were significantly different. As we have noted earlier, the Ministry of National Development building spatialised and projected the image of a modern, progressive state. This space and image is even stronger if we consider that urban renewal was taking place at the same time and the podium-tower typology formed a striking contrast to the low-rise, dilapidated and overcrowded shophouse typology that it displaced. Thus, the hermetically sealed air-conditioned office tower in Singapore was not simply a universal form. It was also a typology driven by and deeply entangled with the post-Independence Singapore state’s developmental agenda of modernising, sanitising and rationalising the built environment. This new environment was in turn conceived by the state as a part of the larger project to socially engineer and discipline the population to turn them into modern subjects and productive workers.

What we see at this juncture then is the emergence of a complex system of interdependent socio-technical and built-environmental components, including the developmental state and its planning policies, the urban typology of podium tower, air conditioning and other building services, building envelope systems, thermal comfort and social practices. The following section turns to the last two of these components through an exploration of how the new form of air-conditioned thermal comfort—one that James Marston Fitch and Lisa Heschong have referred to as ‘thermal steady-state’ and ‘thermal constancy’ respectively—changed social practices, particularly daily routines of working and shopping.

**Enclosing the outdoors**

As the concept of the podium-tower continued to define the approach to new developments, its use extended beyond office towers and associated facilities of banking halls, sales offices, car parks, restaurants and shops. As the 1970s unfolded, many of the podium-tower buildings became ‘multi-use complexes’, in that podiums housed shopping arcades, upon which sat towers of offices, residences and hotels. By 1972, there were at least 12 such complexes in operation in Singapore, including the People’s Park Complex, Peninsula Shopping Centre, Specialist Shopping Centre, Katong Shopping Centre, Tanglin Shopping Centre and Shaw Centre. They were promoted as ‘a shopper’s dream’ as they were ‘air-conditioned and beautifully decorated and stocked with everything that anyone could almost wish to buy under one roof’, and as such associated with a new way of shopping—‘the
instant way and in cool comfort”—and deemed as ‘not a luxury to shop in complexes but a pleasant necessity to save valuable time and energy’. With air conditioning providing what a Carrier advertisement described as an ‘oasis of comfort’ in the new shopping complexes, sales would no longer be affected by the vagaries of bad weather and other external conditions, and operational hours could be longer than the traditional markets and shops that were located along the open streets in the shop-house neighbourhoods.

With air conditioning, what was formerly the exterior street was transformed into interiorised atrium and corridor, cooled, dried and sheltered from the heat and humidity of the tropical climate. A commentator claimed that the cool and comfortable interiorised ‘exterior’ spaces of a shopping arcade would prove to be so popular that the arcade in Singapore would become a ‘new social centre besides being a shoppers’ paradise’. The emergence of these air-conditioned complexes and the attendant spatial phenomena of integration and interiorisation have to be understood in relation to the success of urban renewal. Urban renewal brought about the demolition of shophouses and contributed to the demise of many traditional streets along with the street hawkers and the shops that lined these streets. In place of sweaty bodies intermingling in the crowded streets, going about their activities exposed to the hot and humid weather, the complexes created interiorised—mechanically cooled and artificially illuminated—spaces of comfort and convenience for the crowds (Fig. 9).

In the 1960s–70s we begin to clearly see the interdependence between building typology, architectural design, constructional systems and air conditioning. The introduction of the podium-tower typology locked the builders into the use of mechanical cooling, just as the proliferation of air-conditioned buildings led many designers to discard the external sun-shading devices and to use glass curtain walls as building envelopes. Interdependence was not only restricted to material and technological artefacts, it also affected social practices (Fig. 10). The thermal comfort standard adopted in most air-conditioned buildings around the world was based on experiments done with human subjects in laboratories, primarily in Europe and North America. As E. Shove points out, the underlying assumption is that thermal comfort is an attribute based on a certain standardised set of environmental conditions, independent of diverse socio-cultural contexts.

Any prescriptive standard, however, if widely implemented, does not merely meet people’s ‘need’ as was intended in the comfort experiments. It inevitably will also be involved in changing expectations and affecting social practices, thus altering the very ‘need’ it intends to meet. For example, in the case of AC, people might start to dress differently in order to feel comfortable in an air-conditioned workplace. As Winter has noted, changes also occur in the material culture, along with the daily routines and habits of occupants. By the 1970s, air conditioning as a complex system of interdependent socio-technical and built environmental components had gained powerful momentum and paved the way for an irreversible thermal modernity.
Figure 9. A 1975 advertisement for Carrier’s Mecair air-conditioning system that was used to cool large podium-tower blocks, such as the Shaw Tower in the illustration (source: Carrier Singapore).
Figure 10. An advertisement for Carrier’s Moduline system that shows some of the changes in the material culture of an air-conditioned office: windowless cubicles that are artificially illuminated (source: Carrier Singapore).
that would reach new scales and ambitions from the 1980s onwards, as we will see.

From complexes to ‘cities’

In the decade or so from 1965 to 1974, Singapore’s per capita electricity consumption increased threefold. During that time, three new power stations were built to increase generating capacity, and the power network was greatly expanded. Although the large increase in electricity consumption could be attributed to various factors—including the ambitious post-Independence industrialisation programme—the increasing pervasiveness of air conditioning was undoubtedly one of the main causes. For example, in 1976 air conditioning was estimated to consume about 28% of the electricity generated in Singapore. As a result, the global energy crises of the 1970s triggered some important debates in Singapore concerning energy usage levels across the built environment. Whilst the crisis that affected Europe and North America in the first half of the decade did not really impact Singapore badly, by 1976 seminars and symposia were being organised by the government and professional bodies to discuss architectural use of low and renewable forms of energy.

As air conditioning consumed a large share of the available electricity, making mechanically cooled buildings more efficient was one of the main foci of energy conservation efforts. In a speech to conference delegates, the Minister of National Development, Lim Kim San, noted that ‘most of the multi-storey buildings in Singapore had been built without sufficient thought for minimising recurrent costs on power consumption in air-conditioning’. He offered the example of his ministry’s buildings—in which a 15–20% energy reduction had been achieved through the installation of sun-breakers—as a template for others to follow. One audience member recalled some years later, however, that ‘although the call of energy conservation was endorsed with loud applause, the message did not go further than the auditorium…the old architectural ethos

Figure 11. A 1980 advertisement for a double-glazing system that highlights its good thermal and sound insulation.
prevailed. Examples of energy conserving initiatives were few and far between.\textsuperscript{56}

Nonetheless, the various initiatives undertaken at that time provided a valuable platform for guiding policies subsequently adopted in response to the second major energy crisis of the late 1970s. In 1979 energy-reduction guidelines and bylaws were introduced.\textsuperscript{57} The new regulations stipulated a minimum Overall Thermal Transfer Value (OTTV) for the building envelope, a concept introduced by the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) to calculate how well insulated a building envelope was from heat transmission through conduction and radiation. OTTV was aimed at reducing the heat transmitted from the exterior to the interior of a building and, by extension, the cooling load of the building. The assumption behind OTTV was that a building should be designed in accordance to what Banham calls the ‘conservative mode’: clearly separating the interior of the building from the environment and minimising any heat transfer between the two (Fig. 11). It was an assumption that ran counter to the selective mode of passive cooling previously advocated for the tropics. Instead of producing light and porous buildings that admitted breezes and resisted solar gain, the inclusion of OTTV in building regulations produced hermetically sealed structures, entirely dependent on air conditioning. The introduction of OTTV as a concept to reduce energy consumption was a sign that AC as a complex system had gained so much technological momentum that the expansion of AC was seemingly irreversible as alternative cooling technological systems were excluded from any solution for reducing energy consumption despite the energy crisis.

Indeed, over the course of the 1980s architects looked to supersede existing buildings by creating ever more impressive and spectacular interior spaces. To that end, a new form of development emerged, one that came to be referred to as ‘cities’. Marina Square (completed 1986) and Suntec City (completed 1995) were notable examples of this shift. Marina Square was built on land combined...
from four Government Land Sales sites that added up to 90,000 sq m. As the generic name of the development suggests, the sites were all on reclaimed land adjacent to both the waterfront and the city centre. Marina Square was initially proposed to house 2,000 hotel rooms, a 59,000 square metre ‘shopping city’ featuring four department stores and a supermarket and parking for 2,400 cars.\(^{58}\) The project was thus not just quantitatively large, it was also qualitatively different. Designed by John Portman, who was well known for his spectacular atria in North America, Marina Square reinvented the atrium and brought a new form of interiorised ‘exterior’ space to Singapore. The design included the region’s tallest and largest atria. The Pan Pacific Hotel included a 36-storey-tall atrium (Fig. 12) and the floor plan of the Oriental Hotel’s lobby was equivalent to one and a half football pitches (Fig. 13). Portman’s spectacular atria thus established a new trend for creating dramatic interior spaces for shopping arcades and hotels across the city.\(^{59}\)

This insular sense of being ‘sealed against the real’ was quite apparent in the case of Marina Square. To begin with, it was the first development on a new piece of reclaimed land. There was really no pre-existing context other than infrastructure such as road, drainage, sewerage and electrical systems. The site was thus the ultimate clean slate, requiring no demolition or erasure. Roads were laid out primarily to facilitate vehicular movement, although wide pavements were provided for pedestrians. In response to this non-context, Portman elevated the shopping arcade on a podium one storey above street level,

Figure 13. View of the 36-storey-high atrium of the Oriental Hotel (today’s Mandarin Oriental; source: photograph by Jiath-Hwee Chang).
and the hotels were set back from the roads. Facing the roads and pavements were blank elevations, mechanical exhausts, with car park and service entrances. All roads and pavements became service lanes or residual spaces to which the whole development turned its back. While the ‘real’ city was rejected, another privatised, self-contained ‘city’ was created within Marina Square, with its spectacular atria, interiorised streets and elevated decks. Once shoppers were drawn into the development, they could move to various parts of it without setting foot again on the roads and pavements. In North America, such an insular and interiorised urbanism was part of the phenomenon of ‘splintering urbanism’ that arose from the ‘fear of the traditional street as a place of crime, disorder, poverty, insanity and danger’.60 In Singapore, however, given the orderly and safe nature of the urban environment, we would argue it is more appropriate to read this interiorised urbanism as one of the key manifestations of a thermal modernity.

In the mid-1990s Marina Square was joined by another mega-development, Suntec City (Fig. 14). Owned by a consortium of Hong Kong businessmen...
and designed by Tsao & McKown architects, Suntec City was conceived for a floor area of 7 million square feet. Perhaps as a response to the way Marina Square undermined ‘street life’, the architects of Suntec City received a brief from the Urban Redevelopment Authority (URA) that focused on bringing street life back to the area. The architects’ response was to relate and enliven the streetscape by enclosing those interior spaces that faced onto the ‘streets’ with glass, thus providing visual connections that enhanced the transitory spaces between indoors and outdoors. Two important built features of Suntec City that exemplified such aims were a 5-storey atrium that led to the convention halls and a central fountain plaza designed to provide underground connections to the neighbouring developments, whilst also purportedly generating the sense of a more ‘vibrant urban street life’.61 Despite these features, Suntec City reproduces many of the characteristics of Marina Square, such that it provides seamless interior connections that bypass the ‘streets’, ‘so seamless is the integration of the spacious project that visitors can move in air-conditioned comfort from one end of Suntec City to the other without having to step out’.62 Indeed, the complex required a $400 million mechanical and electrical system with a central chilled-water plant of 23,500 refrigeration-ton capacity, the largest in Singapore and one of the biggest to be installed anywhere in Asia at that time.63

The use of glass-enclosed privatised public space and the planning authority’s new interest in enlivening street life were also manifest in Bugis Junction, another mixed-use development completed around the same time as Suntec City. Instead of demolishing the old shophouses on the site and replacing them with a new building of the podium-tower typology, at the Bugis Junction development (Fig. 15), the old shophouses in Hylam, Malay and Malabar streets were demolished, rebuilt, weather-proofed and air-conditioned. The ‘streets’ between the reconstructed shophouses were covered with a glass canopy and turned into an arcade. This new experience of shopping comfortably in an air-conditioned

Figure 15. The air-conditioned glass-covered ‘street’ of Bugis Junction (source: photograph by Jiat-Hwee Chang).
'outdoors' was regarded as one of the factors that differentiated Bugis Junction from its competitors in ‘a saturated marketplace hungry for novelty’, enabling it to clinch, for two years in a row, the Best Shopping Experience/Shopping Centre award given by the Singapore Tourism Board as part of its annual Tourism Awards.\textsuperscript{64} It also marked yet another important approach to the spatial expansion of air conditioning. Instead of increasing the interiorised ‘exterior’ spaces within a building, as transitions from early complexes to a mega-development like Marina Square and Suntec City had done, Bugis Junction represented an attempt to colonise existing exterior space. More specifically, it is a phase of development that is notable for attempting to ‘preserve’ through air-conditioning the type of streetscape for which Singapore was famous.

It could be argued that the expansion of the scale of air-conditioned spaces, including the colonisation of exterior spaces, would reach its peak in the mid-1990s through the URA’s proposed master-plan for the new downtown in Marina South (Fig. 16): this is located across Marina Bay from Marina Square and Suntec City, and like them is situated on reclaimed land. One of the most distinctive features of the new master-plan was the seamless pedestrianised connections between major transit nodes, such as the underground stations and the elevated walkways, which were in turn linked to individual developments. These connections were not only seamless, they also allowed pedestrians to move in ‘all weather comfort’.\textsuperscript{65}

Although little detail was present in the proposal regarding how ‘all weather comfort’ was to be achieved, given that many of these connections replicated the supposedly ‘street-friendly’ development of Suntec City, the use of vertical glazing and skylights caused air conditioning to be once again pivotal to the design.\textsuperscript{66} Crucially, such large-scale use of air conditioning was made possible by the adoption of district cooling, a technology first implemented in several North American and Japanese cities. In the early 2000s, a new $100 million district cooling plant came online, enabling chilled water to be pumped across a large number of buildings for the purposes of air conditioning. Proclaimed ‘efficiency gains’ of around 15–20\% over conventional methods and the on-going centralisation of cooling infrastructures thus continues the trend of recent decades for ever-larger enclosures of comfort across the city.\textsuperscript{67} Such perpetual scaling, however, by implication effectively negates any claims of percentile efficiencies.

**Entangled modernities of thermal comfort**

As the 2000s progressed, and as debates around urban sustainability have continued to gather momentum, the case for building spaces less reliant upon mechanical air conditioning became ever more compelling. The push towards bio-climatic architecture and urban greening has found its most spectacular and grandiose forms in the work of architects such as Ken Yeang whose high-rise designs seek to offer a solution to an inescapable future of high-density development. Such ecological design has led to an architectural signature combining naturally ventilated spaces, sun-shading, wind-scoops, vertical greening, natural lighting systems and the use of recycled materials.\textsuperscript{68} But
whilst the construction of a number of flagship buildings—such as the National Library opened in 2005 or the Building and Construction Authority’s newly opened academy headquarters, which is proclaimed to be the region’s first zero-energy retrofitted building—undoubtedly constitutes an important development, we would argue that the thermal modernity of air conditioning remains hegemonic in Singapore and will continue to do so for the foreseeable future.

Beyond the ‘conventional’ spaces of conditioned comfort such as offices or homes, the diversity of cooled interiors continues to increase across the urban environment. Interiors on the move—taxis, cars, buses, trains—now carry their passengers between air-conditioned connector spaces, such as underground arcades or transport interchanges. The Toa Payoh bus interchange (Fig. 17), completed in 2002 and the first of many air-conditioned bus interchanges in Singapore’s public housing estates, stands as both metaphor and literal example of the cooled comfortable life of the Singaporean resident. A newspaper columnist notes,

[Toa Payoh Interchange’s] big glass panels allow commuters to see the view outside, knowing that it is scorching hot out there. Yet Singaporeans comfortably place themselves in another self-created, spacious world… As Singaporeans see it, the stark contrast between the world outside and the world inside Singapore is the great achievement of the Government. The Government is trying to make the people stay by satisfying their basic needs and then raising their material expectations gradually to make them feel that they have a stake in the country.69

Over a number of decades air conditioning has become deeply entangled in both the everyday and abstract political realities of Singapore as a nation state. It has formed part of the socio-technical matrix, folding the ideologies of economic development, post-colonial nation-building and state-citizen relationships into an urban development pro-
gramme oriented towards ever-greater levels of indoor comfort. Indeed we would suggest that a social contract has formed between the state and the Singaporean citizen around the provision of what might best be described as ‘comfort security’. In invoking such a term we point towards the production of an urban civic culture over time that has pivoted around concepts of ‘modern, safe, comfortable, efficient and productive’. It is a convergence between the aesthetic and the political, the domestic and the state, which has placed technologies such as air conditioning at the heart of the nation-building process in Singapore since the 1960s. But looking further afield, and as we have noted, air conditioning has been pivotal to the global spread of a particular regime of thermal modernity over the last eighty years or so. Indeed, as our analysis illustrates, it is critical to understand how the ascendency of AC has come about through certain localised, historically specific agenda.

Once seen through the lens of social and political entanglement, the role air conditioning has played as an actant in remodelling the built environment at different scales and reconfiguring the relationship between indoor and outdoor spaces is revealed. Only by analytically elevating AC beyond its role as a technological component of modernist architecture, can we read it as a crucial constituent of a thermal modernity that has, in effect, come to transform how built environments and urban spaces are conceived and inhabited. By examining Singapore in such terms we have sought to retrieve air conditioning from its current place in the background of global architectural history, where it has too often quietly hummed away, ignored, and instead move it forward, giving it the critical attention required to understand its larger impact on modern urban development around the world.

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Notes and references

2. When ‘air-conditioned nation’ was first used to describe Singapore, that particular author was not just referring to the ubiquity of AC in Singapore. He was also using ‘air-conditioned nation’ as a metaphor for the political culture of Singapore. See, C. George, Singapore, the Air-Conditioned Nation: Essays on the Politics of Comfort and Control, 1990–2000 (Singapore, Landmark Books, 2000).


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