

Hybrid Workshop 17-18 Nov 2022

COOLING ASIA

Technology, Environment and

Society in Hot Climates



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Image courtesy of Darren Soh

This workshop is organised by the Asia Research Institute, National University of Singapore; with support from Ministry of Education Academic Research Fund Tier 2 (MOE2018-T2-2-120) – Heat in Urban Asia: Past, Present, and Future.

This workshop examines the relationship between cooling technologies, the environment, and societies in Asia through interdisciplinary perspectives. Cooling technologies include, but are not limited to, those that create airflow, evaporation, endothermic reactions, and refrigeration cycles. They also include broader technological infrastructures, such as airconditioned built environments, produce cold chains, and the electricity and water networks that support them. Residents of Asia have long relied upon such technologies to regulate thermal sensations and to preserve and distribute produce. At the same time these cooling technologies have modified Asian environments across different scales, in both direct and indirect ways. In contemporary Asia, cooling technologies have become a major source of energy consumption and, so, are contributing to both local and global patterns of climate change.

This workshop explores cooling technologies from both historical and contemporary perspectives. Rather than focusing solely upon technological innovation, we intend to also examine these technologies *in use*, and explore them throughout their life cycles, considering multiple dimensions including the socio-cultural adaptation of technologies, maintenance and repair, energy consumption, and pollution and waste. We recognize that our technological infrastructures are shaped by social, political, and cultural choices, and shape these choices in turn. The cooling technologies we choose are influenced by social norms of comfort, health and convenience, but many other factors besides. Cooling technologies are co-constituted with cooling practices and thermal material cultures, as Elizabeth Shove and others point out.

We are indeed interested in an array of cooling technologies for both dry and humid climates. Many of the discussions of cooling technologies tend to be divided into passive and active modes, structural solutions and power-operated solutions, or pre- and post-air-conditioning. We would like to think beyond such binaries to engage with a mix or combination of modes and solutions through not just designed mixed-mode buildings, but also heterogeneous assemblies of technologies and spaces produced through everyday uses; what David Edgerton calls “creole technologies”. In addition, none of the categories is monolithic. Passive mode, for instance, do not just involve hardscapes such as buildings, but also softscapes like landscaping and vegetation. Furthermore, power-operated solutions include technologies of different energy intensities, from low-energy fanning and evaporative technologies to high-energy conventional air-conditioning.

We aim to address “environment” at different scales—e.g. built, urban, and planetary—and if possible, trace their connections. The cooling of one environment might lead to the warming of another, for example: i.e. air conditioning the interior environment of a building might mean putting waste heat to the exterior and exacerbating the urban heat island effect. Furthermore, as air-conditioning is an energy-intensive technology, its use contributes to an increase in carbon emission, as most of the world’s electricity is still generated from fossil fuels that worsen global warming. Hence, one of the key questions of cooling the environment in a time of the climate crisis is: how do we cool ourselves without further warming the planet? To answer this question, we seek to examine cooling technologies and the environments created in relation to what Nicole Starosielski calls “thermal cultures” in which certain thermoceptive regimes are cultivated to further specific social and political ends through biological and environmental manipulations. Such situated understandings of the techno-enviro-politics of cooling are essential to any thinking about the future of cooling in a low carbon world.

WORKSHOP CONVENORS

Assoc Prof Gregory Clancey
National University of Singapore

Assoc Prof Jiat-Hwee Chang
National University of Singapore

Assoc Prof Christopher Courtney
Durham University

SINGAPORE
STANDARD TIME

THURSDAY, 17 NOVEMBER 2022

9:30 – 9:45

WELCOME & INTRODUCTORY REMARKS

GREG CLANCEY | National University of Singapore
JIAT-HWEE CHANG | National University of Singapore
CHRISTOPHER J. COURTNEY | Durham University

9:45 – 11:15

PANEL 1 | CHILLING DATA

CHAIRPERSON **CHAEWON AHN** | National University of Singapore

9:45

Cold Chains of Ice and Data

VIA ZOOM

YURIKO FURUHATA | McGill University

10:05

The Cost of Cool: Singapore's Data Center Moratorium and its Ripple Network Effects

VIA ZOOM

GEORGE RAMIREZ | New York University
IAGO BOJCZUK | University of Cambridge
NICOLE STAROSIELSKI | New York University
ANNE PASEK | Trent University
HUNTER VAUGHAN | University of Cambridge
SORCHA FFRENCH | Trinity College Dublin

10:25

Rethinking Computational Ecologies: How Tropical Data Centers in Puerto Rico and Singapore Contest Thermal Imperialism

STEVEN GONZALEZ MONSERRATE | Massachusetts Institute of Technology

10:45

QUESTIONS AND ANSWERS

11:15 – 11:45

BREAK

11:45 – 12:45

PANEL 2 | THERMAL MAINTENANCE AND DAMAGES

CHAIRPERSON **YOONHEE JUNG** | National University of Singapore

11:45

Meltdowns: Technological Failures, Overheated Properties and Improvisation in India

VIA ZOOM

BHARAT JAYRAM VENKAT | University of California—Los Angeles

12:05

Keeping Affordable Cooling in Motion: Repair, Maintenance and Profits in Karachi's Second-Hand Market for Air Conditioners

ATOOFA HAFEEZ SAMO | Institute of Business Administration Karachi
NAUSHEEN H ANWAR | Institute of Business Administration Karachi

12:25

QUESTIONS AND ANSWERS

12:45 – 13:45

LUNCH

SINGAPORE
STANDARD TIME

THURSDAY, 17 NOVEMBER 2022

13:45 – 15:15

SPECIAL PANEL | THERMAL TECHNOLOGIES IN SINGAPORE

CHAIRPERSON **JIAT-HWEE CHANG** | National University of Singapore

This special panel includes technical experts and scientists sharing with us their latest research on urban heat and techniques of cooling across different scales in Singapore.

MATTHIAS ROTH | National University of Singapore

LI FUYUN | ST Engineering

WONG NYUK HIEN | National University of Singapore

14:45

QUESTIONS AND ANSWERS

15:15 – 15:45

BREAK

15:45 – 17:15

PANEL 3 | THERMAL INFRASTRUCTURES

CHAIRPERSON **CONNOR GRAHAM** | National University of Singapore

15:45

Switching Off the AC: Economies and Ecologies of Thermal Regulation

AMITA BAVISKAR | Ashoka University

16:05

Patchwork/Patched-Up Infrastructure: The Thermal Politics of Re-Calibrating Outdoor Comfort in Singapore

JIAT-HWEE CHANG | National University of Singapore

16:25

Putting Urban Surfaces to Work – White Roofs – ‘Easy Wins’ or ‘Contested Formations’

SIMON MARVIN | University of Sydney

16:45

QUESTIONS AND ANSWERS

17:15

END OF DAY 1

18:00 – 19:30

WORKSHOP DINNER (FOR PRESENTERS, CHAIRPERSONS AND ORGANISERS ONLY)

SINGAPORE
STANDARD TIME

FRIDAY, 18 NOVEMBER 2022

09:30 – 11:00

PANEL 4 | COMMODIFYING COMFORT

CHAIRPERSON **CHRISTOPHER J. COURTNEY** | Durham University

09:30 Air Conditioning the Arabian Peninsula

VIA ZOOM **GÖKÇE GÜNEL** | Rice University

09:50 Colonial Trade and Thermal Comfort as Commodity in 20th C. India

VIA ZOOM **PRIYA JAIN** | Texas A&M University

10:10 Conditioning Modernity: Air-Conditioners in India

VIA ZOOM **ASHAWARI CHAUDHURI** | Cornell University

10:30 QUESTIONS AND ANSWERS

11:00 – 11:30

BREAK

11:30 – 12:30

PANEL 5 | CULTURES OF REFRIGERATION

CHAIRPERSON **JOPPAN GEORGE** | National University of Singapore

11:30 The Revolution Will Not Be Refrigerated: An Alternative Chinese History of Cold Chains
CHRISTOPHER J. COURTNEY | Durham University

11:50 *Kimch'i* and the City: Fermented Foods and Refrigeration Technologies
in South Korea

HYUNGSUB CHOI | Seoul National University of Science and Technology

12:10 QUESTIONS AND ANSWERS

12:30 – 13:30

LUNCH

13:30 – 14:30

PANEL 6 | THERMAL CULTURES AND RHYTHMS

CHAIRPERSON **FIONA WILLIAMSON** | Singapore Management University

13:30 Thermal Comfort and Cooling Technologies Amongst Low-Income Households
and Informal Outdoor Workers in Urban South Asia

ADAM ABDULLAH | Institute of Business Administration Karachi

SOHA MACKTOOM | Institute of Business Administration Karachi

NAUSHEEN H ANWAR | Institute of Business Administration Karachi

13:50 The Thermal Culture/s of Migrant Labour in Singapore: Thermal Autonomy
and Regimes of Productivity

ELSPETH OPPERMAN | LMU Munich, and National University of Singapore

14:10 QUESTIONS AND ANSWERS

14:30 – 15:00

BREAK

SINGAPORE
STANDARD TIME

FRIDAY, 18 NOVEMBER 2022

15:00 – 16:30 **PANEL 7 | (UN)CONDITIONED ARCHITECTURES**
CHAIRPERSON **GREG CLANCEY** | National University of Singapore

15:00 Stranded Assets: The Case of the HSBC Tower (Foster and Partners, 198x, Hong Kong)

VIA ZOOM **DANIEL A. BARBER** | University of Technology Sydney

15:20 From Ancient Cooling Knowledge to Commercialized Air-Conditioning: Tracing the History of Cooling Technologies in Chinese Architecture since 1920s

LI HAIQING | Southeast University

SHEN JIE | University of Tokyo

15:40 Revisiting Traditional Passive Cooling Strategies as Vehicles for Inclusive Architectural Approaches in a Contemporary Indonesia

YASMIN TRI ARYANI | Collecting Otherwise Working Group

16:00 QUESTIONS AND ANSWERS

16:30 – 17:00 BREAK

17:00 – 18:00 **CLOSING DISCUSSIONS AND PUBLICATION PLANS**

JIAT-HWEE CHANG | National University of Singapore

CHRISTOPHER J. COURTNEY | Durham University

18:00 END OF WORKSHOP

Cold Chains of Ice and Data

Yuriko Furuhata

Department of East Asian Studies, and World Cinemas Program,
McGill University

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In recent years, media studies has undergone an “elemental” turn towards thinking about natural environments as part of our communication, transmission, and storage media. This elemental turn has given rise to innovative works by scholars such as Nicole Starosielski and Liam Cole Young who propose to study natural elements such as heat and salt as “media” in their own right. In dialogue with their work, and others in environmental humanities more broadly, this paper proposes to analyze frozen water (snow and ice) as the material support of two different types of infrastructure of circulation: the cold chains of perishable food, and the cooling systems of data centers. My aim is to read these parallel infrastructures of refrigeration (food) and cooling (data) together in order to analyze how and why natural ice and snow became a renewable resource in modern Japan.

From the 1870s to the early 1900s, natural ice was harvested in the northern island of Hokkaidō and sold as a luxury commodity mostly to European and American expats and Japanese elites in the Tokyo metropolitan area. From the 1910s onwards the development of mechanical refrigeration replaced naturally harvested ice with machine-produced artificial ice, laying the ground for the modern cold chain to support the circulation of perishable food. The use of natural ice as a source of coldness soon fell into obsolescence. However, recently, telecommunications and cloud computing service providers began returning to the harnessing of natural snow, this time in order to cool down data centers. Since the 2010s the use of this experimental “green” technology to cool data centers has received attention and investment in Japan. The White Data Center in the city of Bibai in Hokkaidō, which just operationalized its snow-based cooling system in 2022, leads this trend.

Drawing a comparison between the cold chain of ice and the cold chain of data, this paper thus examines how and why snow and ice emerged as a renewable resource in Japan in the two defining moments of the nation’s infrastructure developments: the 1870s and the 2010s. Technically, digital information is not “perishable” in the same as organic matter, such as edible goods. Yet, bits of digital signals are stored, processed, and transmitted by computers, fiberoptic cables, and data centers, which rely on constant thermal regulation, including cooling of heat-sensitive computers. As Starosielski argues in *Media Hot & Cold*, “[m]anaging heat through artificial cold is an integral part of media history” (2021: 194). Heat and humidity are a threat to digital data, just as they are to edible food. By focusing on the history of snow and ice as natural resource of coldness, used to refrigerate and cool down both food and data in Japan, I examine how the commodification of coldness connects the cold chain of perishable food to the cold chain of perishable data.

Yuriko Furuhata is Associate Professor and William Dawson Scholar of Cinema and Media History in the Department of East Asian Studies and an associate member of the Department of Art History and Communication Studies at McGill University. She is the author of *Cinema of Actuality: Japanese Avant-Garde Filmmaking in the Season of Image Politics* (Duke University Press, 2013) and *Climatic Media: Transpacific Experiments in Atmospheric Control* (Duke University Press, 2022). She is currently working on a new book project, titled *The Edges of Deep Time: Archipelagic Archives of the Anthropocene*, which explores scientific photographs and films of fossils, clouds, snow and ice in relation to the settler colonial histories of geosciences in Japan and North America.

The Cost of Cool: Singapore's Data Center Moratorium and its Ripple Network Effects

George Ramirez

Department of Media, Culture, and Communication,
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Anne Pasek

Cultural Studies Department, and Trent School of the Environment,
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Hunter Vaughan

Minderoo Centre for Technology and Democracy,
University of Cambridge

Sorcha Ffrench

School of Law, Trinity College Dublin

Technologies of cooling are shaping the geography of global signal traffic. Fiber-optic cables and the computers they interconnect have long required cooling systems to offset the heat they produce. More recently, these systems have become the topic of public debate, technological struggle, and policy regulation. As a case study, we focus on the recent moratorium of data center construction in Singapore and its reverberation in the global network. Data centers, and to a lesser degree the subsea cable systems that link them, rely on energy-intensive cooling systems. In 2019, in part due to the massive energy draw of data center cooling, Singapore established a three year moratorium that would halt data center construction, prompt a turn to green building, and stimulate new approaches to cooling. We examine the effects that this had on the data center industry, the routing of signal traffic through the country, and new construction in the global subsea cable network. In particular, we look at the emergence of the Sustainable Tropical Data Centre Testbed (STDCT) in Singapore, and the range of new cooling technologies generated specific to tropical environments. We will draw from interviews with data center and subsea cable owners and operators in Singapore in order to document their reactions to this moratorium and their visions of developing as a sustainable hub.

George N. Ramírez is a PhD candidate in the Department of Media, Culture, and Communication at New York University, where his work focuses on sensation and performance in Latinx popular culture.

Iago Bojczuk is a PhD candidate in the Department of Sociology at the University of Cambridge. His doctoral work investigates the material, cultural, economic, and political dimensions of Big Tech infrastructures in the Global South.

Nicole Starosielski, Associate Professor of Media, Culture, and Communication at New York University, is author or co-editor of over thirty articles and five books on media, infrastructure, and environments, including: *The Undersea Network* (2015), *Media Hot and Cold* (2021), *Signal Traffic: Critical Studies of Media Infrastructure* (2015), *Sustainable Media: Critical Approaches to Media and Environment* (2016), *Assembly Codes: The Logistics of Media* (2021), as well as co-editor of the “Elements” series at Duke University Press. Starosielski's most recent project involves working with the subsea cable industry--which lays the transnational links of the internet--to make digital infrastructures more sustainable.

Anne Pasek is an Assistant Professor and Canada Research Chair (Tier II) in Media, Culture, and the Environment at Trent University, cross-appointed between the Cultural Studies Department and Trent School of the Environment. Her research explores the cultural politics of climate change, with a particular emphasis on the social and technical means through which carbon is enumerated and mobilized within diverse social formations, including climate denialism, the tech sector, and the arts. She is also the director of the Low-Carbon Research Methods Group, a network of scholars examining the climate and equity impacts of decarbonizing academic work, and the Experimental Methods & Media Lab, a hub for research-creation and critical making at Trent with a particular focus on emerging climate tech. She is a Co-PI and Energy & Climate Lead of the Sustainable Subsea Networks project funded by the Internet Society Foundation.

Hunter Vaughan is Senior Research Associate at the Minderoo Centre for Technology and Democracy, University of Cambridge. His most recent book, *Hollywood's Dirtiest Secret: the Hidden Environmental Costs of the Movies* (Columbia University Press, 2019) offers an environmental counter-narrative to the history of mainstream film culture and explores the environmental ramifications of the recent transition to digital technologies and practices. He was a 2017 Rachel Carson Center Fellow and is founding editor-in-chief of the *Journal of Environmental Media* (Intellect Press). He is Co-Principal Investigator on the AHRC-funded Global Green Media Network and Co-PI on the Sustainable Subsea Networks project funded by the Internet Society Foundation.

Sorcha Ffrench recently graduated from Trinity College Dublin with a First-Class Distinction in a Master of Laws, with a thesis focusing on environmental constitutionalism. She graduated with a Bachelor of Law and Society from Dublin City University in 2021.

Rethinking Computational Ecologies: How Tropical Data Centers in Puerto Rico and Singapore Contest Thermal Imperialism

Steven Gonzalez Monserrate

History, Anthropology, Science, Technology & Society (HASTS) Program,
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As Langdon Winner writes, “artifacts have politics” (1980). The computer is no different. Designed to operate in cool, temperate climates rather than hot, tropical ones, computers reproduce colonial dynamics (Johnson 2019). Just as the tropics were posed as a foil to the wellbeing of the bodies of European settlers in Asia, Africa, and the Americas (Laveaga 2009), the tropics are today figured as the bane of computational infrastructures. In the tropics, data centers must contend with extremes of heat and humidity, expending more energy to keep servers cool enough to function. In a rapidly warming planet, the energy expenditure of data centers is under increased scrutiny, given that most of the world’s electricity grids are powered by fossil fuels rather than renewable energy sources like solar or wind. With the greenhouse gas emissions of data centers now equivalent with that of the airline industry, how can we justify increasing to build more data storage infrastructure? At the same time, how is it just to ban the construction of data centers in the tropics (a geographic zone which constitutes most of the Global South) and further entrench the digital divide and an extractive digital economy that favors the tech sector and the Global North?

In this paper, I draw from ethnographic fieldwork in Puerto Rico and preliminary interviews in Singapore, to illustrate the ways that data center operators, government officials, designers and adjacent publics are contesting “thermal imperialism”, a design hegemony which favors “Big Tech” and the Global North (Hogan 2018). I think with two case studies that highlight how thermal domain is both political and cultural as well as material and ecological (Starosielski 2021).

Through innovative projects like the Tropical Data Center (TDC), a private and public sector partnership in Singapore, the operational limits of computers are being contested. By running servers in data centers at heat and humidity thresholds greater than the standards set by The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Singaporean data center operators are reimagining the thermal ecology of computing and are charting a course to transform their city-state into a sustainable datapolis (Ong 2016; Rossiter 2017).

In Puerto Rico, data center operators must weather catastrophic hurricanes in addition to extremes of heat and humidity of the Caribbean tropical zone. In the aftermath of Hurricane Maria data centers were among the few places with electricity and network access in the island of Puerto Rico (Bonilla 2017). While the public struggled to survive without power or access to clean water, servers thrived. Revolting against this injustice, several data center operators transformed their facilities into thermal refuges for displaced citizens without access to air conditioning in the heat wave that followed the hurricane.

Steven Gonzalez Monserrate is a PhD Candidate in the History, Anthropology, Science, Technology & Society (HASTS) program at the Massachusetts Institute of Technology. His dissertation, “Cloud Ecologies”, is an ethnographic investigation of data centers and their environmental impacts in New England, Arizona, Puerto Rico, and Iceland. “Cloud Ecologies” explores a range of themes including; masculinity in tech, ideologies of waste and sustainability, thermodynamics, IT cooling, data storage futures, electronic waste, noise pollution, and the increasing water and carbon footprints of digital infrastructure. Steven’s work appears in public venues such as *Aeon*, *README*, *ABC News*, *Popular Science*, *Scientific American*, *The Wire*, and *MIT Press Reader*. Steven holds an MA in Anthropology from Brandeis University and a BA in Feminist Anthropology from Keene State College.

Meltdowns: Technological Failures, Overheated Properties and Improvisation in India

Bharat Jayram Venkat

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The visual repository of extreme weather events has its stock photographs: damaged and destroyed homes, families adrift on broken furniture amidst a flooded landscape, and in the case of extreme heat, warped and distended roads and pastoral scenes deprived of life and riven by cracks. As Hamstead and Coseo have recently argued, the governance and reportage of such events is discursively framed around the twin poles of life and property. In practice, however, both governmental investments and news coverage have focused rather disproportionately, and perhaps unsurprisingly, on property. “We have inherited,” Hamstead and Coseo write, “a Western meteorological practice that was designed to defend and protect property and commerce.”

Rather than concede to this bifurcation of the world into life and property, we might think instead of lives and properties, in the plural. Lives have properties, such of which are not necessarily related to possession. Properties might not be owned, or might be owned in common, or might be related to in ways that are non-possessive. Turning to examples provided by Hamstead and Coseo—“melted asphalt, warped rail, and power outages”—I am struck by the sense that what is damaged is not one’s personal property per se, but rather an infrastructure held in common that provides the literal grounds for civic life and sociality—which is also, of course, inextricability bound up with the movement of capital. Roads and rails, after all, transport both people and goods, bringing us to work as well as to our loved ones. In this sense, the damage inflicted by heat is not simply to property or (biological) life, but also to what we might crudely gloss as social, political, and economic life.

My aim is to examine a range of examples of heat-inflected damage to a variety of things—organic and inorganic, living and nonliving—bound up with human life. As a scholar of science, medicine, and the environment in India over the course of the long twentieth century, I’ve found innumerable examples of heat-related damage to forms of property, broadly construed: vaccines, X-rays, photographic plates, telegraph wires, computers, even potatoes. Such damage goes by a variety of names: overheating, melting, shorting out, buckling, spoiling, deteriorating, denaturing, rotting, and so forth. Each of these varied modes of damage indexes a particular relation between heat and materiality, while simultaneously revealing a relationship between the properties or affordances of these materials and the human lives organized in and through them. A major aim of this paper will be to think through the ways in which such properties are preserved and protected. What, in other words, are the modes of “cooling” particular to varied things, and how does this relate to the particular ways in which they are damaged by heat? A key argument will be that the development of these “cooling” measures was often ad hoc and improvisatory, as a response to the particular and often unexpected interaction of heat and the properties of things.

Bharat Jayram Venkat is an assistant professor at UCLA’s Institute for Society & Genetics and in the Department of History. His research focuses broadly on questions related to science & medicine, ethics, race, environment, and design. His first book, *At the Limits of Cure* (Duke University Press, 2021), was the winner of the Joseph W. Elder Prize in the Indian Social Sciences. Through an anthropological history of tuberculosis treatment in India, this book asks about what it means to be cured, and what it means for a cure to come undone. His current book project, tentatively titled *Swelter: A History of Heat in an Unequal World*, is about thermal inequality and the science of thermal sensation. In conjunction with this research, Dr Venkat also directs the UCLA Heat Lab. Through the lab, he mentors a diverse group of students invested in researching thermal inequality and justice from a variety of disciplinary perspectives.

Keeping Affordable Cooling in Motion: Repair, Maintenance and Profits in Karachi's Second-Hand Market for Air Conditioners

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As temperatures rise and heatwave alerts intensify in Pakistan's largest metropolis Karachi, air-conditioners, coolers and fans are switched on and markets for cooling appliances flourish. Despite the South Asian region's deep history of living with heat, longer periods of extreme heat due to climate change are pushing people's experiences of heat beyond coping thresholds (Coleman, 2020). Over the past year, we have been looking at formal and informal markets for cooling appliances to understand how small-scale businesses play an essential role in delivering affordable, refurbished cooling technologies that are instrumental in shaping the rising demand for cooling in Karachi—a city of 25 million residents and where approximately 62% live in informal/low-income settlements underserved by clean water and uninterrupted electricity.

In this paper, we explore what it means to profit from heat: How does the demand for cooling appliances open profit-making opportunities in Karachi? In 2018, Pakistan (population 220 million) accounted for 0.7% of the total global demand for air conditioners, with an estimated demand of 824,000 units out of 111 million globally. The ownership of air conditioners in Pakistan is relatively low: only 13.1 percent of urban households own an air conditioner (Pakistan Bureau of Statistics). Moreover, in Karachi approximately 12 percent of households own an air conditioner. However, the demand for air conditioners is rising in Pakistan's urban centers, as people struggle to cool off during summers and that too in a context where temperatures have risen in cities like Karachi by at least 1.5 °C over the past 60 years (Anwar et al., 2022).

The repair of cooling appliances, such as second-hand refrigerators, air coolers and air conditioners, is the cornerstone of livelihoods and profits in the city's largest second-hand market for cooling equipment: the Jackson Market established during British colonial rule. Taking a cue from Guyer (2004), we understand the 'second-hand' markets/economies for cooling technologies as places of "marginal gains" and "maximal gains"—to distinguish large-scale profit making from everyday efforts to seek a return on a transaction. We see these markets as crucial for understanding the contemporary forms of profiting and the fundamental role of "social payments" rather than market logics. Since the informal/second-hand markets uphold the refurbished/affordable cooling devices, we underscore repair practices located within markets. Particularly, we explore the ways in which repair is placed at the point where profiting of the overall market and livelihoods of laborers are conjoined, and how their experiences, struggles and expertise make the market functional and set their economies in motion (Anwar & Sur, 2020; Strebels et al., 2019; Isenhour & Reno, 2019).

Even though disproportionately hotter cities in South Asia present a challenge for sustainable energy, this leads us to question who has access to cooling in conditions of extreme heat. Energy demand for space cooling is expected to more than triple by 2050 with severe impacts on the poor (Khosla et al., 2020; Mastrucci et al., 2019). In thinking about cooling demand, we are mindful about how to place cooling in relation to the SDG 7 and SDG 13, as there is a global call for action to reduce Greenhouse Gas Emissions (GHS). Keeping in mind the importance of GHS, we push for a deeper understanding of cooling in relation to the cooling needs people demand as a protective measure to save lives in conditions of extreme heat.

Atoofa Samo is a Senior Research Associate at Karachi Urban Lab. She holds a Master of philosophy in Social and Cultural Anthropology from Quaid-e-Azam University, Pakistan. At KUL, she has been developing ethnographic case studies on second-hand air conditioning markets and looking at the notion of profiting from heat, while also developing an understanding of patchwork -repair practices embedded in everyday life of the labourers at the interplay of profits and fixing fragile objects. Her research interest includes anthropological explorations of weather folklore through prominent fictional stories at the intersections of heat, weather, and human-environment interactions in South Asian context.

Nausheen H. Anwar is the Founder and Director of the Karachi Urban Lab (KUL) and Professor City & Regional Planning in the Department of Social Sciences & Liberal Arts (SSLA), IBA, Pakistan. Nausheen is also a Fellow in the Cities Cluster, IDS, University of Sussex. Nausheen is a member of the World Health Organization's (WHO) and World Meteorological Organization's (WMO) Technical Advisory Group on informing decision-making about indoor heat risks to human health.

SPECIAL PANEL**Thermal Technologies in Singapore**

This special panel includes technical experts and scientists sharing with us their latest research on urban heat and techniques of cooling across different scales in Singapore.

Matthias Roth

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Li Fuyun

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Matthias Roth is a Professor in the Department of Geography at the National University of Singapore. He holds a Diploma from ETH, Zurich (Switzerland) as well as MSc and PhD degrees from the University of British Columbia, Vancouver (Canada), all in Physical Geography. His research examines how land-use changes affect local climates with a particular focus on the climate of cities and the role they play in climate change. As an experimental researcher he has conducted observations of the urban heat islands, energy balance, carbon dioxide fluxes and fundamental turbulence properties in cities located in North America, Europe and Asia. Besides fundamental aspects of the surface-atmosphere exchanges, he is increasingly interested in the application of such knowledge to the climate-sensitive design of cities. He is Past President of the International Association for Urban Climate (IAUC), Associate Editor of the *International Journal of Climatology* and a member of the editorial boards of *Urban Climate* and *Singapore and Journal of Tropical Geography*.

Li Fuyun is Head of Sustainable Cooling for Urban Solutions in ST Engineering. With over 15 years' experience in R&D particularly in sustainable environmental engineering product development, Dr Li actively introduces new sustainable cooling technologies in various areas, covering outdoor/semi-open spaces, building energy efficiency and sustainability as well as data centre related products and applications. For his contributions to sustainable technologies, Dr Li received the Young Green Innovator Award from SGBC-BCA in 2019, Tan Kah Kee Young Inventors' Silver Award (2013), and the Institution of Engineers, Singapore's Prestigious Engineering Achievement Award (2010). Dr Li holds a PhD in Chemical Engineering from the National University of Singapore.

Wong Nyuk Hien is currently Vice Dean for Graduate Research Programmes of the College of Design and Engineering and Professor at Department of the Built Environment. He has completed his PhD in Building Performance and Diagnostics from Carnegie Mellon University, USA in 1998. He has been the Principal Investigator for research projects funded by the various Singapore government agencies such as URA, HDB, JTC, NParks and NEA to study Urban Heat Island effect in Singapore and to explore the various mitigation measures. Some of the key research projects that he has been involved include Marina Bay New Financial Centre, Punggol Waterway, One North and Resort World Sentosa. Prof Wong is also instrumental in the study of the thermal benefits of Urban Greenery such as Green Roofs and Vertical Greenery Systems. He also collaborated with BCA in developing the suitable thermal comfort assessment models for Green Mark Scheme. He has published more than 200 research articles in journals, and 21 book/ monograph contributed as author/co-author.

Switching Off the AC: Economies and Ecologies of Thermal Regulation

Amita Baviskar

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Scholars argue that air-conditioning is a powerful socioeconomic and technological complex, one that breeds and sustains itself as a seemingly vital component of contemporary life (Winter 2013). Analyses of how built environments and social behaviour have adapted to incorporate increased use of air-conditioners (ACs) present a totalizing scenario of spatial control and social segregation: 'thermal monotony' and 'agoraphobia.' The broad contours of this analysis can be usefully applied to North Indian cities, which have experienced a similar surge in domestic and public use of ACs and concomitant changes in environments and lifestyles (Baviskar 2022). However, closer examination shows that, even among those who have access to them, AC use is neither ubiquitous nor uniform. Users' class, age and gender locations shape how they use ACs, as do their beliefs about the body and the self in relation to a changing environment. While economic concerns about the cost of running ACs are an important factor in limiting their use, so also are ideas of health that valorise self-discipline and attunement with 'natural' ecologies and climates. Using participant observation and interviews, I examine the micro-practices of AC use in Delhi and, by exploring the ambivalence that people express about it, attempt to arrive at a more nuanced account of cooling at the confluence of global technologies and indigenous/traditional knowledge systems about health and wellbeing. I shall discuss how such socio-cultural calibration of cooling may dampen (and even reverse) the dire prognostications about the spread of ACs as standardizing lived spaces and lifestyles.

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Patchwork/Patched-Up Infrastructure: The Thermal Politics of Re-Calibrating Outdoor Comfort in Singapore

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As many scholars have noted, infrastructures are “conceptually unruly” because they are complex, heterogeneous, and inter-connected assemblages that exist on many levels simultaneously. Furthermore, an infrastructure is both a thing and a connection between things (Larkin, 2013). But thermal infrastructure is probably more complex than other infrastructures for a few reasons. Unlike water, electricity, transport, and telecommunication infrastructures, thermal infrastructure is not an established notion that provide known services. Furthermore, a thermal infrastructure could potentially refer to a few different things—from large continuous interiorized air-conditioned spaces and district cooling systems that Singapore is known for (McNeill, 2019) to heat action plans and OSH (occupational safety and health) legislations for dealing with heat wave and work-related heat stress respectively. The outdoor thermal infrastructure of Singapore that is the focus of this paper relies on non-mechanical means and low- or zero-(operational)-energy technologies for cooling. For the past forty to fifty years, this low-energy, outdoor thermal infrastructure existed in parallel to the energy-profligate, indoor thermal infrastructure. It could be seen as an alternative to the “carbon/thermal modernity”¹ of air-conditioned infrastructure. But it is probably not something that many would think of because of its patchiness and patched-up-ness. It consists of many different spatially and temporally layered components—physical structures like covered walkways and pavilions, landscape features like trees and vertical greenery, and low-carbon novel cooling technologies—built by an array of actors. These parts were also constructed in various historical moments for different purposes, with thermal consideration being only one among others and entangled with other socio-political priorities.

This outdoor thermal infrastructure is thus both patchy and patched-up. It consists of different components built up over time and unevenly distributed across space. These components interact with existing built environment to augment and complement their thermal performance by retrofitting and connecting the urban fabric, and through the contingent acts of mending gaps and filling in voids. The patchiness here does not suggest the type of unequal infrastructural provision that one sees in splintering urbanism (Graham & Marvin, 2001). But as this outdoor thermal infrastructure is either built by or highly-regulated by state agencies, they provide insights into the thermal governance of Singapore. Unlike that presented in *Singapore: The Air-Conditioned Nation* (George, 2020), the thermal politics of small city-state is not as centralized and based on a single logic of “comfort and control” if we study the histories of the making of the outdoor thermal infrastructure and the attendant recalibration of outdoor thermal comfort.

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¹ For thermal infrastructure, see (Chang & Winter, 2015). Carbon modernity is the phrase Eleni Myrivili, the Chief Heat Officer of Athens, used to describe the underlying energy and material logic behind the construction of modern air-conditioned architecture that turned cities into heat traps (Myrivili, 2022).

Jiat-Hwee Chang is Associate Professor of Architecture and Research Leader of the STS (Science, Technology and Society) Cluster at the Asia Research Institute, National University of Singapore. He is an interdisciplinary researcher working at the intersections of architecture, environment and STS. He is the author of *A Genealogy of Tropical Architecture: Colonial Networks, Nature and Technoscience* (2016), which is awarded an International Planning History Society Book Prize 2018 and co-author (with Justin Zhuang and Darren Soh) of *Everyday Modernism: Architecture and Society in Singapore* (2022). He is currently working on a book manuscript on the socio-cultural histories and techno-politics of air-conditioning and climate change in urban Asia. Jiat Hwee is also the co-editor of two books and several special journal issues. Jiat Hwee's research has been supported by institutions in North America, Britain, Germany, Australia, Cyprus, Qatar and Singapore. He was recently a Carson Fellow at the Rachel Carson Center for Environment and Society in Spring 2020, a Manton Fellow at the Clark Art Institute in Fall 2019, and a Canadian Centre for Architecture – Mellon Foundation Researcher, 2017-19.

Putting Urban Surfaces to Work – White Roofs – ‘Easy Wins’ or ‘Contested Formations’

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During extreme heat events urban surfaces emerge as critical zones where the worst excesses of disruptive heat become manifest and can also be modulated to maintain life. Roads and runways start to melt, hard pavement surfaces can exceed 70°C, and the unprotected feet of the homeless suffer serious burns. Yet modified surfaces can also be configured as useful thermal tools. White roofs can reflect heat, retrofitted green, water and nature-based landscapes can provide cooling, and new technologies for responsive building envelopes can more effectively manage heat. This paper examines the ways in which urban surfaces have been a focus for understanding the circulation of heat in the urban environment and their emergence as the key site for technical and material interventions designed to modulate heat during extreme weather events. Conceptually the paper draws on surface studies and infrastructure studies to focus on two key insights to understand the opportunities, tensions and limits of mobilising and experimenting with urban surfaces as a metropolitan thermodynamic tool. The first is surface studies that has developed a relational view that prioritises the work surfaces do in actively mediating socio-material relations between different environments. Rather than seeing a surface as a simple boundary we seek to understand the ways in which urban thermodynamics have focused on surfaces as both problematic and a solution to overheating. The second is infrastructure studies which has shown that the development of new socio-technical systems designed to intervene in the urban milieu rarely survive the intentions of their designers when they meet the messy social and political context of everyday life. Rather than seeing surfaces as simple, flexible and easily malleable we use these insights to consider the issues of obduracy, contestation and even resistance to reconfigured surfaces. The paper explores these issues by focusing on the what is frequently characterised as the most ‘low hanging fruit’ for mobilising surfaces as thermodynamic tools—the introduction of white roofs. It focuses on a case study of the proposed mandate to introduce ‘white roofs’ in Sydney as a heat management strategy. This was largely viewed by the science and environmental policy community as an uncontroversial easy win that could be rapidly and easily translated into action. Yet as the paper explores a wider surface politics was revealed by the proposal that ultimately led to the rejection the mandate. The paper argues that understanding the malleability of urban surfaces requires a more than thermodynamic approach to the circulation of heat in the urban environment and needs to consider the social, cultural and material issues in putting surfaces to work for thermal modulation.

Simon Marvin—my work is focused on the analysis of the changing relations between *infrastructure and the urban condition*, and explores social, economic and material interrelationships across diverse technologies in different urban contexts. This work has significantly influenced research in architecture, human geography, technology studies, environmental studies and urban planning. There are three core contributions: first, the reconceptualization of urban infrastructure within a socio-technical, politically networked analysis often called the ‘infrastructure turn’; second, empirically rich and conceptually informed critical geographies of urban sustainability, urban ecological security and low carbon *urban transitions analysis*; and a framework for the analysis of the governance challenges of *urban technological innovations*, including transitions, smart, retrofitting, robotics and automation. More recently I have been interested in the ways that urban authorities and their public and private partners have sought to modulate heat in the urban environment in order to maintain life and operational infrastructure during extreme overheating events.

Air Conditioning the Arabian Peninsula

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With much of the Arabian Peninsula characterized by hot and arid weather conditions during long summer seasons, residents are forced to rely on air conditioning to cool their surroundings. Before the construction of air conditioning infrastructures, many would leave the coast during the summer months to head to oases, such as Al Ain near Abu Dhabi, or live in tents in the desert to find relief from the heat. From the 1950s, European and American building practices shaped the region with little consideration of vernacular design elements or energy conservation. These building practices introduced air conditioning as a cooling method. For instance, the 1951 Report of Operations to the Saudi Arab Government by the Arabian American Oil Company explained how “automobiles, air conditioning units, sewing machines, washing machines, refrigerators, and many other modern conveniences are now readily available” in Al Hasa, a significant region for Aramco’s operations on the east of Saudi Arabia. **1** By 1952, workers residing in Aramco’s camps could have air conditioning units installed in their rooms on a rental basis. **2** Air conditioning technology reconfigured urban environments, altering the relationship between indoors and outdoors, and ultimately constituting what Jiat-Hwee Chang and Tim Winter term a “thermal modernity” that transforms how built forms are imagined and inhabited. **3** The current widespread use of air conditioning in the region is therefore connected not only to high temperatures, but also to how air conditioning is singled out as the ultimate technical fix in confronting the climate. Other solutions to managing heat, such as improving insulation mechanisms for residences and office buildings, have been less pervasive.

Gökçe Günel is Associate Professor in Anthropology at Rice University. Her first book *Spaceship in the Desert: Energy, Climate Change, and Urban Design in Abu Dhabi* (Duke University Press, 2019) focuses on the construction of renewable energy and clean technology infrastructures in the United Arab Emirates, more specifically concentrating on the Masdar City project. Her articles have been published in *Ephemera*, *Anthropology News*, *Public Culture*, *Anthropological Quarterly*, *The Yearbook of Comparative Literature*, *The ARPA Journal*, *Avery Review*, *The Fibreculture Journal*, and *PoLAR* among others.

Colonial Trade and Thermal Comfort as Commodity in 20th C. India

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This paper will chart how the advent and marketing of thermal comfort in India, through the import and sale of foreign-made air conditioners, refrigerators, etc., occurred within channels of long-standing colonial trade. As these capitalist trading firms strived to create a market for manufactured comfort, they drew on centuries of business acumen and local experience to simultaneously homogenize and “other” the world inhabited by the colonizers and the colonized. Through archival research in technical and marketing literature of trading and manufacturing firms, this paper will situate the import of these engineered goods to India within the much longer export of raw materials and produce (cotton, coir, coffee, etc.) from India. It will identify how the extractive infrastructures of colonial trade informed the introduction of carbon-intensive thermal technologies in India. More specifically, it will investigate the impact on creation and manipulation of built space. It will question how the lived experience of building, working and staying cool in India by the colonial traders, furthered, and at times conflicted, with the promotion of these technologies that demanded radical social, cultural and behavioral changes in the lives of its users. The research will identify issues centered on health, hygiene, cleanliness, nutrition, noise, social class and official rank, that were often used to advance these changes. The paper argues that the context of colonial trade uniquely set the stage for the introduction and adoption of thermal comfort in India. This historical analysis aids the understanding of later growth, present trends and the future of climate technologies in India and the Global South.

Priya Jain, AIA, is an Assistant Professor in the Department of Architecture and Associate Director of the Center for Heritage Conservation at Texas A&M University. An architect licensed in both the US and India, she has worked on the reuse and restoration of a diverse range of buildings. Her teaching and research focus on twentieth-century South Asian architectural history and preservation within a transnational context. In particular, she explores how machinations of race and class figure in the marketing, export and adoption of architectural ideas and technologies. Her work has been published in the *Journal of Architectural Education* (JAE) and *Future Anterior* and funded by the Cooper Hewitt Smithsonian Design Museum, amongst others. Priya serves on the Heritage Conservation Committee and the Women in Architecture Affiliate Group of the Society of Architectural Historians. She is Field Editor (Architecture) for the Getty Conservation Institute and sits on the Editorial Board of the JAE.

Conditioning Modernity: Air-Conditioners in India

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In 1937, a newspaper article in *The Hindu* titled “Air Conditioned Train—Demonstration Run—Comfortable and Dust-Proof” in India, described the experience of the first air conditioned train between Delhi and Agra as “smooth and noiseless as a modern ship’s cabin, it was inside. The clatter and din of the ordinary railway carriages was deadened to a subdued sound”. Throughout the twentieth century, when technologies like air conditioners and refrigerators steadily made inroads into everyday Indian existence, they often signified a lot more than comfort or convenience. They were symbols of class, status, and modernity. Based on archival materials, the paper traces some of these meanings associated with air conditioners in the twentieth century and connects them with perceptions about heat and tropicality during the colonial period. This paper is part of a co-authored article on the history of air conditioning in India.

Ashawari Chaudhuri is Visiting Assistant Professor in the STS Department at Cornell University, USA. She is an anthropologist of the environment, science, and medicine. Ashawari’s current book manuscript is a historically grounded ethnography of agricultural biotechnology in India. Along with asking what a good seed is for farmers and biotechnologists, she traces how knowledge about objects like genetically modified seeds is formed at intersections of practice, people, and time. Her next project is an inquiry into the long relation between environmental heat and the body in South Asia. She finds historically emerging meanings of words and concepts powerful. Her teaching is often grounded in questions of ethics and creative negotiations with power around practices, technologies, and ideas that acquire palimpsests of meanings over time and across place. She has lived in India, Singapore, and the U.S. Ashawari knows Bengali, Hindi, English, and she has been learning Mughal Persian for the past few years. Her research and teaching are infused with her own senses of self, belonging, and identity. When she is not teaching or doing research, she is interested in healing plants, stars, and cultural interpretations of dreams.

The Revolution Will Not Be Refrigerated: An Alternative Chinese History of Cold Chains

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The capacity to maintain cold chains revolutionised the modern world. This seemingly banal aspect of the technical infrastructure of modern states played a critical role in the evolution of medicinal and food supply. It therefore contributed to the momentous nutritional and epidemiological transitions that occurred in the twentieth century. Whereas today the form that cold chains assume is fairly homogenous, the historical development of these systems varied considerable between regions. This paper focusses upon one idiosyncratic variation, that which developed in Maoist China (1949-1976). This was a society which was, due to economics and politics, compelled to take an alternative approach to cold modernity. Although China possessed a small refrigeration industry before 1949, this was insufficient to meet the demands of a rapidly industrialising society. Finding itself alienated from both American and Soviet technological systems, China had to develop its own alternative technological cooling solutions. This paper explores a number of these long-forgotten technologies, including the coal-powered refrigerator and the air-raid shelter air-conditioner. It also explores innovative solutions such as the vacuum flask cold chain, which would play an instrumental role in vaccination campaigns in China and beyond in the mid twentieth century.

Chris Courtney is Associate Professor (Modern Chinese History) in the Department of History at Durham University. He is a social and environmental historian of China, specialising on the history of Wuhan and its hinterland. His previous research focused upon the history of nature-induced disasters in the 19th and 20th centuries. His monograph *The Nature of Disaster in China* examined the history of the 1931 Central China Flood, and was awarded the 2019 John K Fairbanks Prize. Chris has also published on topics including the history of environmental religion, fire disasters, and Maoist flood (mis)management. His current research focusses on the problem of heat in modern Chinese cities. Using a combination of archival and oral history he is examining how people coped with extreme temperatures through a period of rapid cultural, political and technological change. He explores how emergent technologies such as ice factories, electric fans, and air conditioning transformed the cultural and social landscape of urban China.

Kimch'i and the City: Fermented Foods and Refrigeration Technologies in South Korea

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Kimch'i is the ultimate “soul food” for most Koreans. Koreans around the world today enjoy the fermented cabbage mixed with chili powder as a side dish to their daily bowl of rice. Many foreigners recognize *kimch'i* as a symbol of Korean culinary culture, which is in turn utilized as a convenient shorthand in the national public relations effort. In recognition of its importance in Korea’s social fabric, in 2013 UNESCO inscribed “Kimjang, making and sharing kimchi” on the representative list of the intangible cultural heritage of humanity. As UNESCO explained, *kimch'i* was made in relatively large quantities in the late autumn to “ensure every household has enough to sustain it through the long, harsh winter.”

This paper focuses on the period during which the Korean living environment changed dramatically. The transformation from a predominantly rural to urban society beginning in the mid-1960s, characterized by columns of high-rise apartments in Seoul, posed unprecedented challenges to the widespread practice of preserving *kimch'i* through the winter. The typical method of *kimch'i* preservation was to store it in large earthenware pots (*jangdok*) and half-bury them in the shade. This ensured the maintenance of low, but not freezing, temperature, allowing the fermentation process to take place at an appropriate rate as the “long, harsh winter” progressed. In the new apartments, however, the traditional practice was no longer feasible. How to store *kimch'i* in the new urban environment soon emerged as a critical social problem.

The growth of apartment-style housing roughly coincided with the spread of refrigeration technologies. For quite some time, however, the early refrigerators and other auxiliary technologies failed to provide a satisfactory solution to the problem of *kimch'i* preservation. In this paper, I will trace the genealogy of technologies developed and mobilized to solve this problem, from simple Styrofoam sleeves to stainless steel jars. For the growing urban population, the *kimch'i* problem remained a source of chronic frustration. It was only in the mid-1980s that large electronics companies began to think about developing the *kimch'i* refrigerator, utilizing advanced technology to regulate and maintain adequate temperatures adjusted to the fermentation process. These efforts to tailor technology to local needs, I argue, represented a major deviation in the collective attitude toward technology among experts and the public in South Korea.

Hyungsub Choi is associate professor of history of science and technology in the College of Liberal Arts, Seoul National University of Science and Technology. He is currently working on a book manuscript on the importation, localization, and indigenization of technology in modern Korea. Choi has served as an associate editor of the *Korean Journal for the History of Science*, editorial board member of *East Asian Science, Technology and Society*, and the executive council of the Society for the History of Technology.

Thermal Comfort and Cooling Technologies Amongst Low-Income Households and Informal Outdoor Workers in Urban South Asia

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This paper explores the interaction of cooling technologies and applied cooling practices through which low-income urban residents and informal outdoor workers navigate thermal discomfort, both indoors and outdoors. We thematically conceptualize the usage, improvisations, and alterations between various kinds of technologies and practices. The study is situated in Karachi, Pakistan, where ambient summer temperatures range between 30-42 Celsius. Using preliminary data from extensive fieldwork over summer 2022, we discuss the experiences of thermal (dis)comfort and heat management strategies, as well as a variety of conventional/available cooling technologies versus improvised/spontaneous cooling practices deployed by the survey participants. Within the household, we explore how erratic pulsations of essential infrastructures (electricity and water) affect cooling practices, especially the purchase and use of cooling technologies. For outdoor workers, we examine how their mobility and limited control of the working space determines their choices around shade, clothing materials, hydration, and the changes in everyday routines due to thermal discomfort. We posit a conceptual model for *applied cooling practices* (comprising cooling materials, cooling cuisines, and cooling routines) that stand-in as improvisations when cooling technologies become unavailable to households and workers.

Adam Abdullah has a PhD in City and Regional Planning from the Middle East Technical University, Turkey, and is Associate Director at the Karachi Urban Lab, IBA, Karachi. He is a lecturer at the Social Sciences and Liberal Arts Department (SSLA) at IBA, Karachi. Adam's interests include data visualization and mapping, urbanization trends, socio-spatial trajectories, and the intersection of urban indicators with social themes.

Soha Macktoom is an Architect, with a Master's degree in Urban and Regional Planning from NED University of Engineering and Technology, Karachi. She is Associate Director at the Karachi Urban Lab at IBA, Karachi. She also teaches as adjunct faculty at Indus Valley School of Art and Architecture (IVSAA) and at the Social Sciences and Liberal Arts Department (SSLA) at IBA. Her work looks at physical transformations of the built environment, with an emphasis on how architecture, design and history are tools for understanding the city's informal settlements, urbanization trends, infrastructure and climate.

Nausheen Anwar is the Founder and Director of the Karachi Urban Lab (KUL) and Professor City & Regional Planning in the Department of Social Sciences and Liberal Arts (SSLA), IBA. She received her PhD in Urban Planning from Columbia University. Nausheen is also a Fellow in the Cities Cluster, IDS, University of Sussex. Nausheen is a member of the World Health Organization's (WHO) and World Meteorological Organization's (WMO) Technical Advisory Group on informing decision-making about indoor heat risks to human health.

The Thermal Culture/s of Migrant Labour in Singapore: Thermal Autonomy and Regimes of Productivity

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This paper draws on Nicole Starosielski's (2019) concept of thermal cultures to examine the thermal regime of migrant labour in Singapore. It begins by situating the bodies of migrant workers within a more-than-human, vital understanding of the thermal, as occurring across a thermodynamic (material/energetic) plane that transgresses scales and means of cooling: from cellular elements of human thermoregulation, to the transfer of water through drinks, showers, humidity, to behavioural modifications of exposure and exertion, removal of clothing and seeking cooler spaces of habitation or work, to use of passive and mechanical cooling at work or in dormitory settings, to the global circulations—not only of climate change—but of heat-absorbing labouring bodies between countries and continents. The key role of human agency in co-producing the thermal indicates that it is a socio-material/energetic plane, shaped by deeply rooted and more immediate operations of power and knowledge.

The paper then outlines the different thermal discourses of heat at play in contemporary Singapore, noting a transition from a 'work, work, work' mentality to a thermal-physiology informed understanding of worker productivity as dependent on health and safety. Interwoven with these discourses are those rooted in traditional thermal cultures, most clearly exemplified in Traditional Chinese Medicine and Ayurvedic practices, performed by Singaporean citizens, migrant labourers from PRC, and from India and Bangladesh. These mesh with and diverge from the western scientific model that increasingly informs the emerging thermal regime in Singapore.

The key relations of power that characterize the contemporary thermal regime are then considered; how they operate, the knowledges and values they are informed by, and the ends they serve. The comfortably airconditioned lives of contemporary Singaporeans, Permanent Residents, expatriates and tourists, are heavily dependent on the thermal exposure endured by the migrant workforce. More importantly, this thermal exposure amounts to thermal violence insofar as workers are not adequately protected or afforded the ability to recover effectively from their day's labour. Their thermal agency is, in other words, heavily restricted. Here we see a thermal regime that relies on and reproduces the political and economic exclusion of migrant workers, motivated by a drive for control and profit, but with undertones of dehumanisation along the lines of class, ethnicity and race.

In this context, calls to reduce air conditioning are revisited, asking instead: where and for whom should it be provided? For workers whose cooling capacity is stretched to the maximum as a result of exposure and exertion, air conditioning is one of the few ways they can recover and avoid thermal harm. Furthermore, in dorms of between 4 and 24 people, it represents one of the most efficient uses of the technology for maximum benefit, a benefit that plays out not just in the comfort of worker bodies, but in the broader biopolitics of productive migrant labour. Airconditioning in dormitories thus not only helps redress and avoid thermal violence, but supports a shift to a thermal regime of health and wellbeing, by utilizing the polyvalence of discourses of performance and productivity.

Elspeth Oppermann is a senior research fellow at the Rachel Carson Center at LMU Munich and a visiting Senior Research Fellow in the Human Performance Translational Research Programme at the Yong Loo Lin School of Medicine, National University of Singapore. As a CI on the UK-ESRC funded project Cool Infrastructures, and Work Package lead for Project HeatSafe (funded by NRF, Singapore), she conducts ethnographic and discourse analysis work on how worker and low-income communities encounter and manage extreme heat in the context of climate change, drawing on theories of social practice, rhythm analysis, post-structural and more-than-human theories.

Stranded Assets: The Case of the HSBC Tower (Foster and Partners, 198x, Hong Kong)

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This presentation develops out of a larger stream of research and teaching I have been developing under the conceptual figure of *Stranded Assets*. A stranded asset, in resource economic parlance, is a known reserve—of oil, coal, or natural gas—that is no longer economically viable to extract. While numerous fields have been abandoned on these terms, as technologies advance they are often re-opened. Implicit already is the recognition that resource extraction corporations generally will not strand assets at will; rather, social processes (politics, cultures of demand management, architecture) must actively force their hand (“Leave it in the Ground!”). In this general, resource context, stranding assets is a vital aspect of organized resistance to the ongoing global fossil fuel regime—a desperate plea to recognize the social costs of carbon emissions.

In borrowing this term from resource economics, and applying it to architecture, I aim similarly to suggest that the social cost of carbon—the impact, that it is, of continued carbon emissions on global social conditions, present and future—is already far too high. By what process can we strand some of our historical assets, functionally and conceptually? Many of the most treasured buildings in the history of architecture are also some of the worse performing – the Seagrams Tower in Manhattan is the most egregious, but one could also look to the Bauhaus Dessau, the Portland Building, the Maison de Verre. These and other valued buildings will need to be radically reconfigured, even reconstructed, to maintain operational viability after carbon. In order to research *Stranded Assets*, my students and I have been simultaneously producing what we call a “Fuel Portrait,” a regional-, urban- and building-scaled analysis of the buildings’ energy input and performance; as well as exploring potential retrofit strategies so that these buildings can somehow remain viable without fossil fuel inputs.

The HSBC tower presents a challenging case study. While clearly valued in the field, isn’t it primarily valued as a sustainable building, i.e. an asset that does not need to be stranded? If only. The building was designed at the beginning of what we could call ‘the sustainable era’—it not only demonstrates technical shortcomings (i.e., relative to today’s standards, poor performance), it also clarifies a poverty of ambition that characterized sustainable architecture broadly considered—a nibbling at the edges relative to carbon emissions, alongside a deep enmeshment in the systems and processes (such as global finance) that maintained a global carbon hungry system. HSBC (the building and the corporation, that is) helps us to understand with some clarity, in other words, exactly how it is that after 40 years of sustainable architecture carbon emissions from buildings continue to rise apace.

This workshop presentation will be far from a completed paper. As some attempts were frustrated by the pandemic, I have never been to Hong Kong and not seen the building. I will present the general methodological context of the *Stranded Assets* project and then rely both on specific secondary literature (including Alexandra Quantrill’s epic analysis of the building in *Grey Room*) as well as general literature on energy policies and regimes in Asia, historiographic considerations of sustainability (in architecture and political economy), and the challenge of reducing carbon emissions in the building industry. I will also reflect on the methodological contours of a historical project that is explicitly projective.

Daniel A. Barber is a Professor of Architecture at the University of Technology Sydney (UTS). His research focuses on environmental dimensions of architecture’s past, present, and future—he is especially interested in how the pedagogy and practice of architecture are changing along with the climate emergency. Daniel has held teaching positions and fellowships in the US, Portugal, and Germany—most recently as a Senior Research Fellow at the Centre for Apocalyptic and Post-Apocalyptic Studies (CAPAS) at the Universität Heidelberg. Daniel co-edits *Accumulation*, an annual dossier of essays on the e-flux architecture online platform and is on the editorial board of the *Journal of Architecture*. His latest book is *Modern Architecture and Climate: Design before Air Conditioning* (Princeton UP, 2020); see also the article “After Comfort” (Log 47, 2019). He received a 2022-2023 Guggenheim Fellowship for his project Thermal Practices.

From Ancient Cooling Knowledge to Commercialized Air-Conditioning: Tracing the History of Cooling Technologies in Chinese Architecture since the 1920s

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By examining the inflow of modern cooling technologies into China and the rapid development of precise cooling technologies represented by air conditioning in the second half of the twentieth century, this study tries to reposition the changes and impacts of cooling technologies in the transformation of modern Chinese architecture within the context of East Asian cultural history of technology.

In the first half of the twentieth century, the “cooling project (冷气工程)” as an early form of modern cooling technologies, was applied on a small scale in high-rise buildings or theaters in Shanghai, Guangzhou and other coastal metropolises. Until the 1960s, the technology of air conditioning has been introduced in China and has advanced rapidly following the Chinese economic reform. From the earliest experiment in textile factories, in train, then in the government office buildings, and finally to everyday life use, air conditioning has quickly permeated every aspect of life and significantly altered daily routines in China. Although the prevalence of air conditioning raised thermal comfort to a certain standard, the traditional Chinese wisdom (“ice cellar (冰窖)”, “self-rain pavilion (自雨亭)”, “cooling house (凉屋)”, etc.) to deal with the hot climate also gradually faded, as evidenced by the increasing rarity of building forms used for “enjoy the shade (纳凉)”. On the other hand, prior to the ruling of air-conditioning, Chinese architects’ practice does not lack of consideration and experiments on passive cooling strategies for hot climate conditions. For instance, Hsia Chen-Si (夏昌世) explored numerous passive environmental control design strategies with his colleagues at South China Institute of Technology during the 1950s and 1960s, forming a characteristic of exploring modern architecture in Southern China before air conditioning fully ruled the built environment in China. Then, with the economic development and improvement of urban infrastructure circuits, air conditioning entered Chinese households rapidly and widely after the 1990s. Since then, attention has been paid to the energy consumption of air conditioners in China, and starting in 1999, minimum room air conditioner energy efficiency standards implemented in 1989 began to be revised and optimized.

Based on early newspapers, related Journal records, and archive of cooling equipment manufacturing enterprises, this study attempts to grasp several important stages of the transformation of cooling technologies in Chinese architecture from a macro perspective; and then by taking Southern China as the main focused area, the history of applying the air conditioning technologies on buildings there is further examined in the context of the intersection between “cooling” technologies, “thermal” culture and “socialist” politics, to reposition the role of air conditioning technologies, and, to trace the transformation of architectural form and the consequent shift in perceptions of thermal comfort —air conditioning is neither the beginning nor the end.

Li Haiqing is Professor of Architecture at Southeast University. He has been teaching here for nearly 30 years at both undergraduate and graduate levels. The courses include building construction, architectural design and historical reviews of architectural technology, etc. He also was a visiting scholar at ETH Zurich and Norwegian University of Science and Technology. Since 1999, Li was among the first to commence the investigation of the history of Modern architectural technology in China. His research interrogates the building mode in the context of global mobility, and the impact of concept on design practice. He is the author of the books, *Modern Transformation of Chinese Architecture* (中国建筑现代转型), and *Further Exploration of Modern Transformation—Research on the History of Technology of Indigenized Modern Architecture in China* (再探现代转型—中国本土性现代建筑的技术史研究). His numerous papers were published in Chinese and English journals. His work, “Xuan’en No.1 Granary” exhibited at the 17th Venice Architecture Biennale, 2021. He also won the “Excellent Guide Teacher Award” for instructing outstanding students’ design works at the UIA-HYP CUP International Student Competition in Architectural Design, 2015.

Shen Jie is PhD candidate in Architectural History at the University of Tokyo. She holds a BArch from Hunan University (2017) while spending one year at the Politecnico di Milano for Chinese government-sponsored undergraduate exchange program (2016) and earned a master’s degree with Distinction in Architectural design and theory at Southeast University (2020). Jie’s doctoral research is supported by Japanese Government (MEXT) Scholarship. Jie was also a recipient of SOM China Prize (2019) for supporting her master’s research work. Building on her focus on the production of architectural knowledge in so-called “peripheries,” her current research is exploring transfer of housing construction technologies that beyond the master architectural contexts towards Global South during the cold war period.

Revisiting Traditional Passive Cooling Strategies as Vehicles for Inclusive Architectural Approaches in a Contemporary Indonesia

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As a home to more than 1,300 ethnicities, Indonesia has various traditional houses that reside throughout its 17,000 islands, exist in different altitudes facing diverse weather conditions of tropical climate. These houses demonstrate the use of passive cooling technologies that allow the inhabitants to overcome the sweltering heat of the dry season, while also enduring the heavy rainfall of the rainy season. Over time, the Indonesian government has used these traditional houses for political reasons, such as turning some of them into a symbol for identity representation, especially that of dominant ethnicity. The government have a tendency of asking architects designing contemporary government-funded buildings to accessorize the buildings with blatant replications of elements of traditional houses. Such an approach could unintentionally lead to the marginalization of ethnic minorities that are not represented there. Many Indonesian architects have shunned this approach and shifted their focus to more essential aspects of traditional house that are relevant and could contribute in solving current energy and environmental issues. Most of them reference the passive cooling strategies applied in traditional houses that exist in close proximity to the site they are working on. This paper will cover several chosen case studies to unfold how the application and transformation of traditional passive cooling techniques could result in more inclusive architectural practices that embrace diverse traditions without excluding minorities. The case studies vary from government-funded projects to cultural and educational institutions. In addition, the chosen case studies exist in different parts of Indonesia that exercise different building traditions. From overhang roof and porous wall designs to the choice of natural materials and local craftsmanship, the case studies show the many possibilities of traditional passive cooling techniques in being a vehicle for architects to deal with the tropical climate while negotiating with their clients' demands to integrate local cultures and traditions in their designs.

Yasmin Tri Aryani is a researcher and illustrator. She holds an MA in Design Curating and Writing from Design Academy Eindhoven. Her research explores the way traditional architecture has been used to represent national identity since the colonial government time in Indonesia. In 2019, she was chosen to be a part of the M+/Design Trust research fellowship, where she highlighted various approaches exercised by Indonesian architects in embracing local traditions that champion inclusivity. Aryani also initiated Coo-Critique, a critique platform that uses animated illustration, at the 2021 Bandung Design Biennale to revisit the idea of traditions in architectural practices in Indonesia. Currently, she is a part of Collecting Otherwise Working Group, where she observes the situation around A.F. Aalbers' architectural works in Bandung. Instead of focusing on the design, Aryani looks at how people interact with the buildings and what kind of interventions has been made to such colonial heritage.