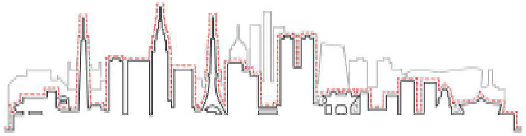
SHIBUYA HEATSINK

SIMULATED ANALYSIS OF URBAN FORM AND ITS THERMAL ENVIRONMENT

-REASSESSMENT OF THE SHIBUYA MASTER PLAN-



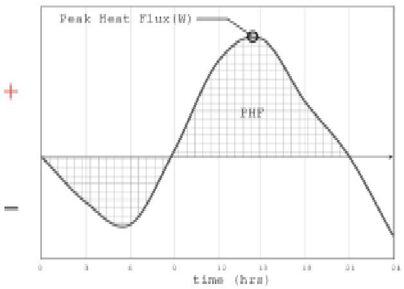
THERMAL ENVIRONMENT

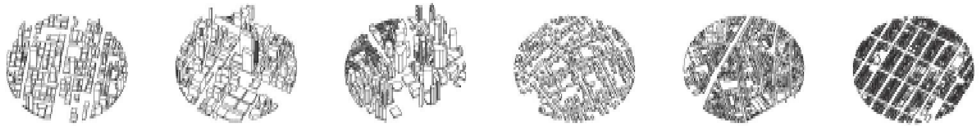
Heat Island Intensity (HII) has been one of the standard indexes for defining the thermal environment of an urban area with respect to UHI. However, another index termed as Heat Island Potential (HIP) , was introduced by Dr. Hoyano of Tokyo University of Technology which gives us a more detailed view of the degree of UHI through heat simulation. In the case of HIP, all possible heat emitting factors are taken into account and simulated to calculate the surface temperatures of the outward facing (fluid surface facing) solid surfaces. The temperature difference between these surfaces and the atmospheric temperature is combined over the entire "skin of the city" and then divided by the projected plane area of the city block. When this value is +ve, heat is being fluxed into the atmosphere and when -ve, it is being absorbed by the buildings.

While HIP looks at the heat flux at that very instant in time, there is a necessity to also understand the total sensible heat that can be potentially fluxed by a city over a period of time. Potential Heat Fluxed (PHF) as an index was therefore developed specifically for the purpose of this study.

$$HIP = \frac{\int_{all\_surfaces} (T_s - T_a) dS}{A} \quad ...(Eq. 1)$$

HIP:	Heat Island Potential (℃)
Ts:	Surface temperature (℃)
Ta:	Atmospheric temperature (℃)
A:	Projected area of the city block (m^2)
dS:	Surface area differential (m^2)



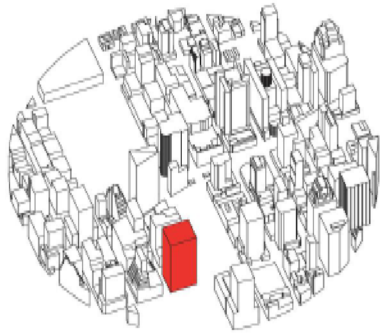


URBAN FORM

Since there was a need to define an urban form through a numerical method in order to compare its physical forms to each other. Quantitatively, looking at a building form within a city, it can be defined by its Volume(V), Radius(R) from the centre, Height (H), Surface Area (SA), Plan Area (A) and Angle (L) from the centre. The urban form, being a collective of these buildings can thus be defined by the mean(μ), Standard Deviation (σ),Total (Σ) and No. of (n) of the variables that define a building.

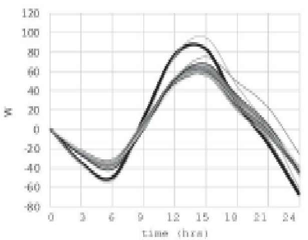
Building Form

Urban Form	V	H	A	SA	R	L
μ	μ_V	μ_H	μ_A	μ_{SA}	μ_R	μ_L
σ	σ_V	σ_H	σ_A	σ_{SA}	σ_R	σ_L
Σ	Σ_V	Σ_H	Σ_A	Σ_{SA}	Σ_R	-
n	n_V	-	-	n_{SA}	-	-

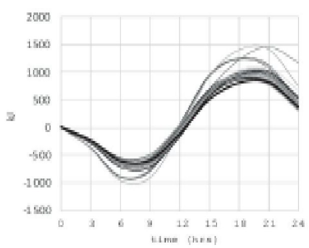


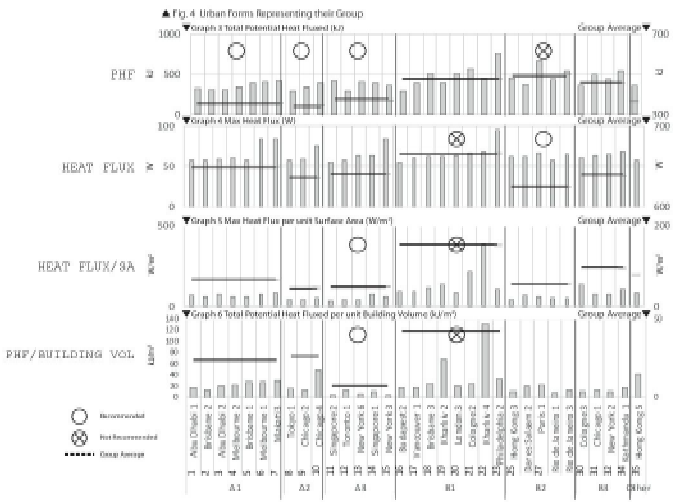
HEAT ANALYSIS RESULTS

Heat Flux Graph for All Cases



Heat Energy (kJ) dissipated All Cases



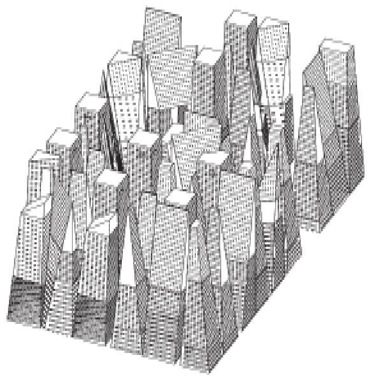


CONCLUSION

Mathematical models for the purpose of defining an urban form and its thermal environment were derived and developed in this study. They were further tested by using them as tools to benchmark urban forms with respect to their physical form and resultant thermal environment.

In conclusion:
Urban Forms under the group of A3 (Mega-Lean), offered the right balance between heat dissipation, heat flux and provisioning of building space.

Although there is a general impression that high density urban areas are unsuitable for UHI because of the concrete build up, this study showed it to be the contradictory as the Mega-Lean Structures had the highest building volumes. Congested Metropolises are better for reducing the overall thermal out flux compared to sprawling ones although the rate of heat dissipation may be on the higher side. To summarize, High building density with lean building forms helps reduce the overall UHI while providing sufficient building space. While there may be other technical, legal, social, psychological, political, cultural and economic considerations, this simulative study suggests that with regard to the thermal environment resulting from solar insolation and wind flow, "Towards a" Mega-Lean Urban Form is recommended.



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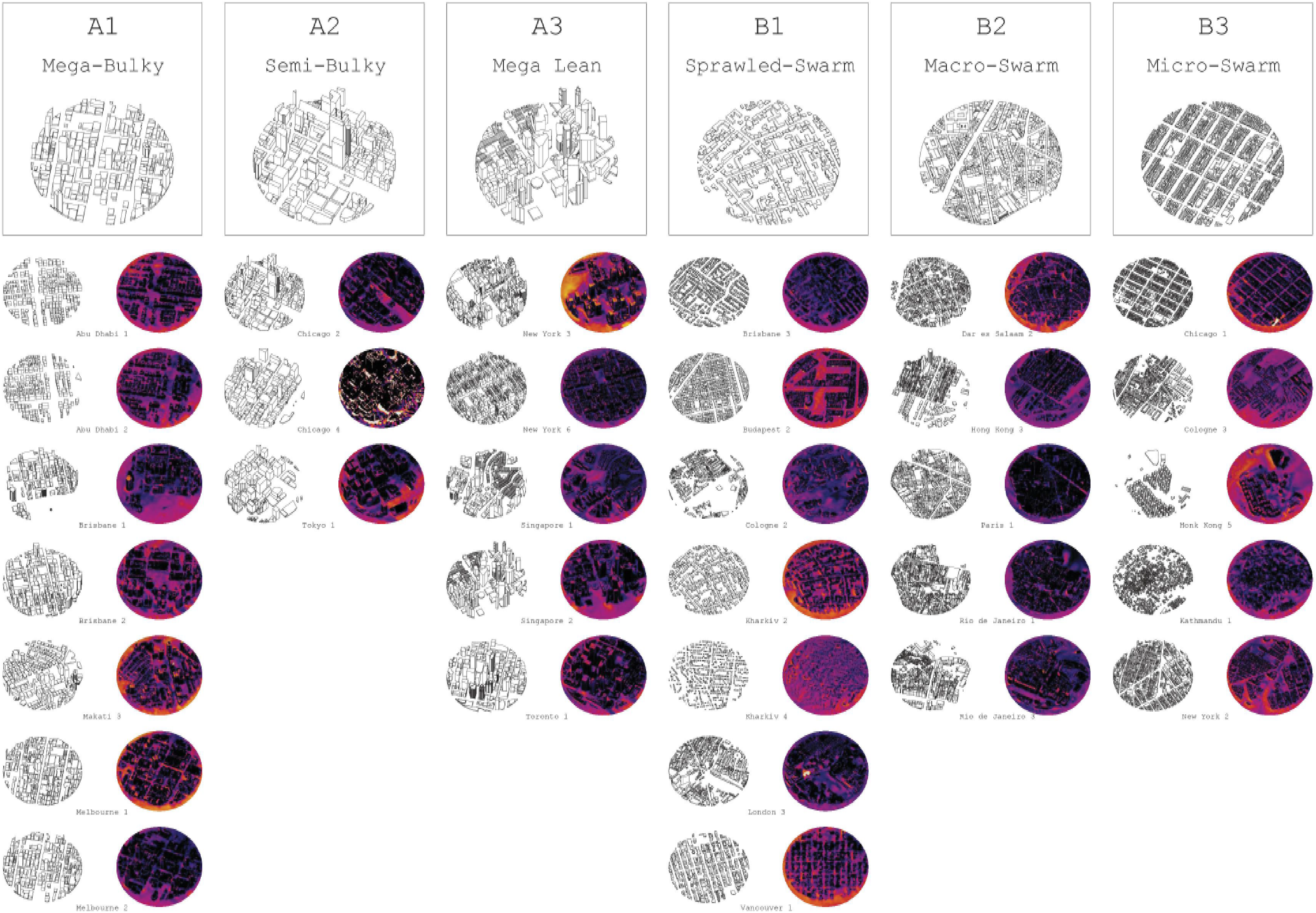
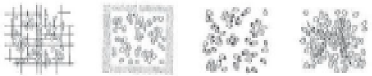


A1
Mega-Bulky
A2
Semi-Bulky
A3
Mega Lean
B1
Sprawled-Swarm
B2
Macro-Swarm
B3
Micro-Swarm
Abu Dhabi 1
Abu Dhabi 2
Brisbane 1
Brisbane 2
Makati 3
Melbourne 1
Melbourne 2
Chicago 2
Chicago 4
Tokyo 1
New York 3
New York 6
Singapore 1
Singapore 2
Toronto 1
Brisbane 3
Budapest 2
Cologne 2
Kharkiv 2
Kharkiv 4
London 3
Vancouver 1
Dar es Salaam 2
Hong Kong 3
Paris 1
Rio de Janeiro 1
Rio de Janeiro 3
Chicago 1
Cologne 3
Honk Kong 5
Kathmandu 1
New York 2

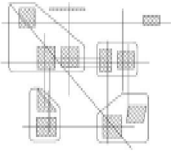
DESIGN BACKGROUND

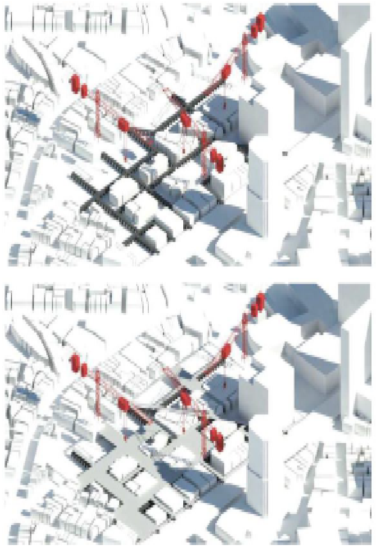


Shibuya's 2030 Master Plan shows a redevelopment plan at a scale that occurs maybe once every 50 to 100 years, the whole town of Shibuya is planned to completely change. Modern high-rise buildings will mushroom around the station and will greatly change the current cityscape of Shibuya including the station building. However the insight gained from this study showed the master plan's urban form leaning towards the Mega-Bulky urban form, which is inadvisable to achieve a thermally acceptable urban form. The same volumes were incorporated and a superblock tending towards a more advisable, Mega-Lean Urban Form was proposed.

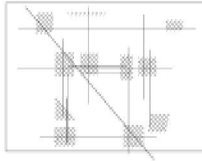
Maki's operational categories were applied to "lead" the development toward the recommended physical form. While Maki's operational categories generally exist individually, this design aims to incorporate multiple operational categories into the same area. In order to articulate each region (building upwards), the suitable operational categories need to be predeveloped in order to "lead" the next stage of construction towards the final urban form. For example, to go from a chaotic, divided urban form to a more well defined and compact urban form, Mediation and Definition using bridges are first applied, which usher the next stage of development to build forms within the borders set by these bridges. The development stages work building upwards rather than horizontally as it slows down the metabolitic rate of construction.

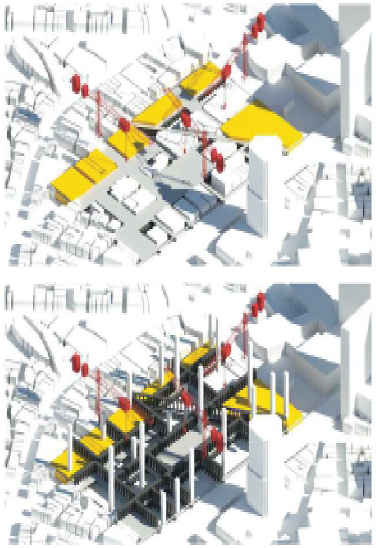
DEFINE AND MEDIATE



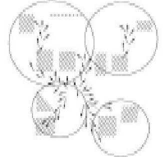


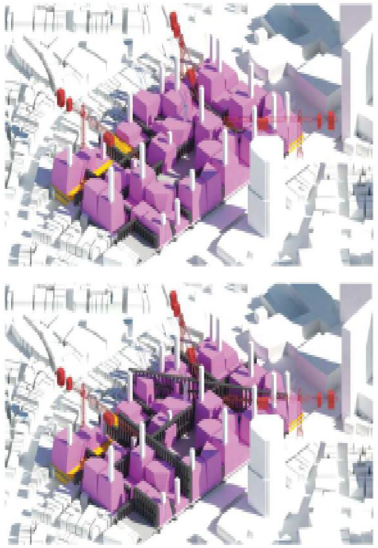
DEFINE AND MEDIATE



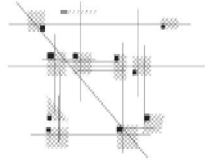


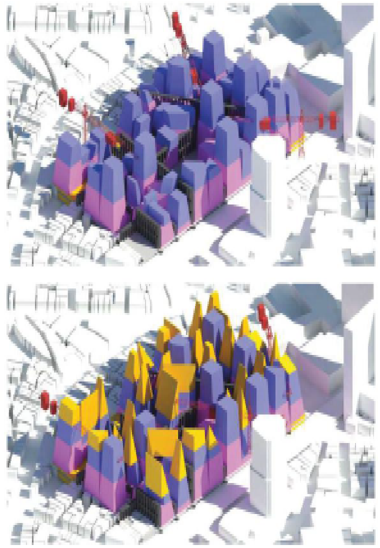
SELECT AND SEQUENCE





REPEAT AND MEDIATE

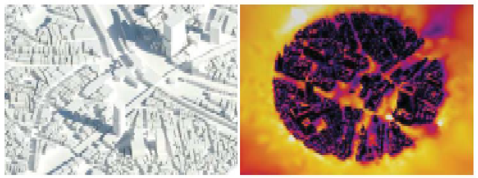




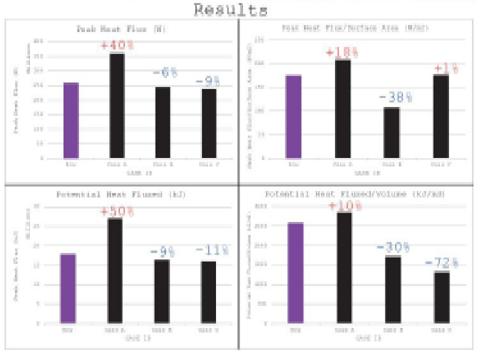
SIMULATIVE ANALYSIS

The proposed design, along with the 2027 Shibuya Master Plan were run through heat and wind simulation in order to calculate their respective heat fluxes. Conclusively, as seen in the results below, Case A (2027 master plan) raises the heat flux and PHF values. We can conclusively say that the 2027 masterplan is not recommendable and will lead to a worse thermal climate.

AT PRESENT

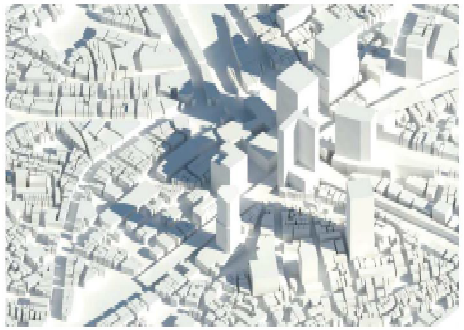


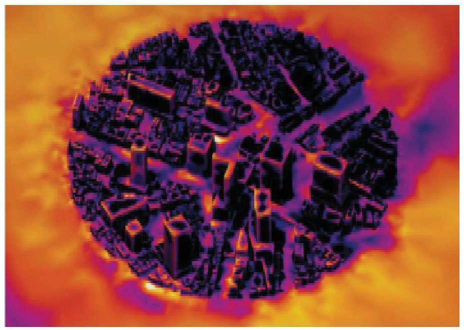
Results



CASE A

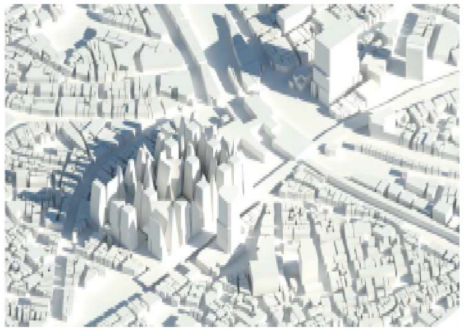
2027 MASTERPLAN

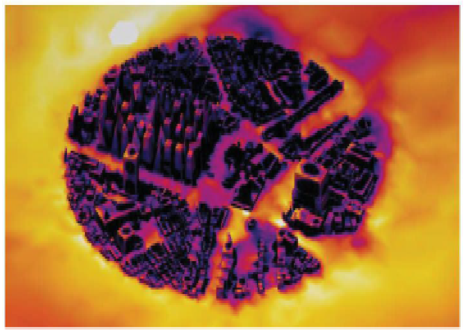




CASE B

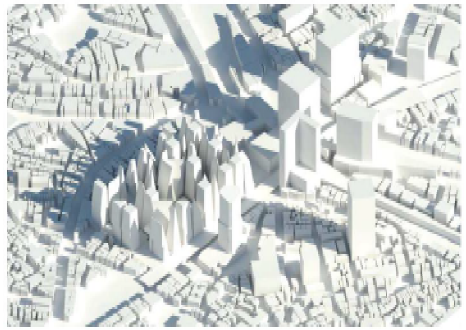
SHIBUYA HEATSINK

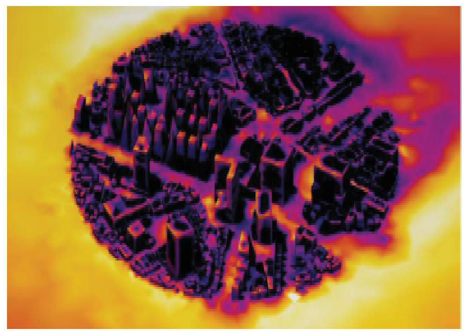




CASE C

2027 + PROPOSED





PHYSICAL FORM

The physical form was principally dictated by the thermal aspects of the design. This form is recommended as it has high building density and lean volumes. However, one of the main disadvantages of a Mega-Lean form is that it still has a high rate of dissipation. This issue was solved by giving each singlar building form a lean form that narrows as you go higher. This increases the sky factor and allows for better heat dissipation. However, there was a dire necessity to translate this Physical Form into an Urban Form. BIGNESS & COMPLEXITY therefore became the key subjects of this masterplan. Bigness because we were dealing with heat island, a phenomenon which exists at an urban scale. Complexity, because we were dealing with a form that is a collective of forms. Of the many different urban theories I chose Maki's collective form for this translation as it deals with bigness and complexity at the perceptive level of architects.