Urban Climate Lab

East Midtown Urban Heat Island

Graduate Program in Urban and Regional Design

NYIT School of Architecture and Design
ARCH 824
Spring 2017

Introduction

The **NYIT Urban Climate Lab** engages New York City as a climate laboratory, contributing to the critical dialog in New York City and other cities confronting climate change. Students research the intersection of urban form, low-carbon cities, and climate to prepare for 21st century urban design practice. The Urban Climate Lab configures compact districts in NYC to adapt and thrive in changing climate conditions, meet carbon-reduction goals, and sustain urban population.

Confronting the challenges of a rapidly urbanizing world threatened by climate change requires expanding the agency of urban design, integrating climate science, natural systems, and compact urban form to configure dynamic, desirable and healthy communities. Global climate challenges are major threats to modern cities, and New York City in particular will be affected in many ways. By 2050, the average temperature in New York is expected to increase by 4.1°F[1]. This will result in major stress on its residents, who will face longer and more frequent heat waves as well as an increase in the number of heat-related deaths.

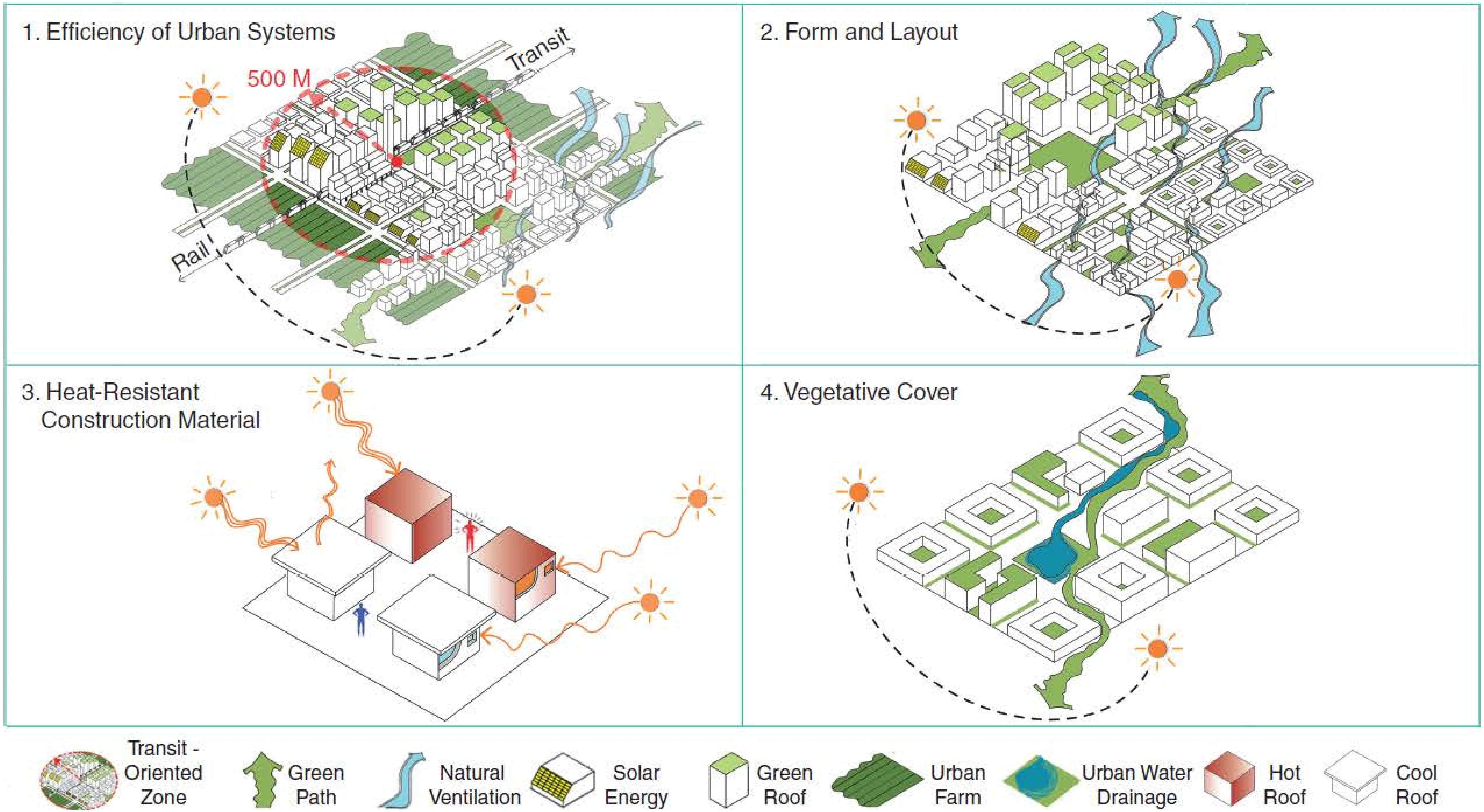
Drawing from leading-edge urban climate research and digital tools, the Spring 2017 Urban Climate Lab explores innovative urban design approaches for the redevelopment of Midtown East Manhattan-- NYC's premier Central Business District-- whose ambitious rezoning plan is now under review by the New York City Council. The lab is inspired by research from the forthcoming publication *Climate Change and Cities* (Cambridge University Press, 2017). The Urban Climate Lab tested the hypothesis that re-configuring urban form according to climate-resilient principles will strengthen East Midtown's adaptability to climate change, reduce energy consumption in the built environment and enhance the quality of the public realm. Building massing, urban ventilation, solar impacts, green infrastructure and anthropogenic factors shape the outcome.

Graduate Program

NYIT's graduate program in urban and regional design is a three-semester (1.5 year), 36-credit, post-professional Master Degree for those holding a first professional degree in architecture, landscape architecture, or planning, with an emphasis on physical design of the built environment. The contemporary field of urban design is fluid, fast-moving, and global. Our graduate program confronts the challenges of urban design in the context of 21st century cities and regions.
www.nyit.edu/maurd

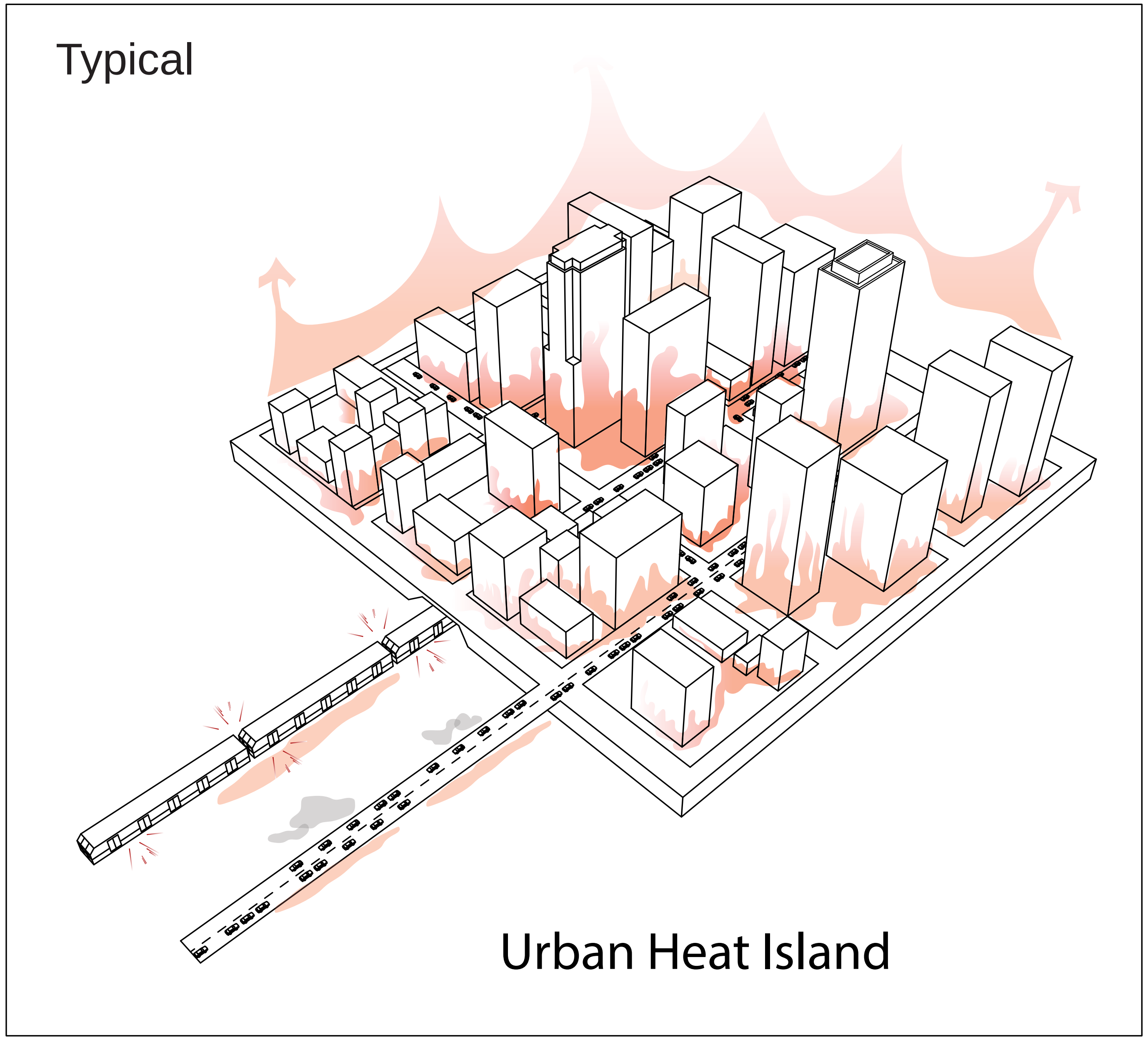
1 NYC Panel on Climate Change (2015)

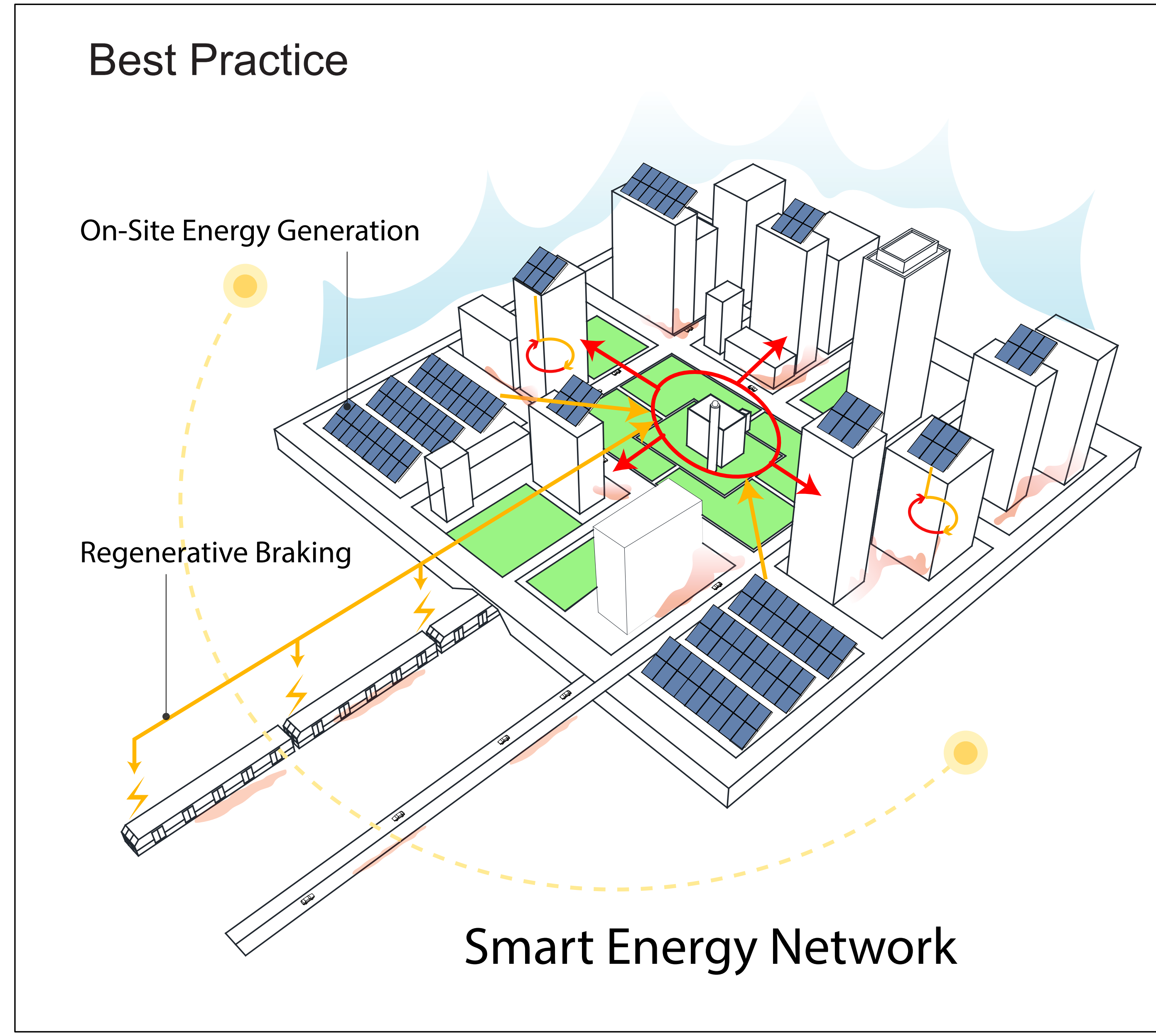
Urban Climate Factors



Jeffrey Raven 2016

Smart Energy Network

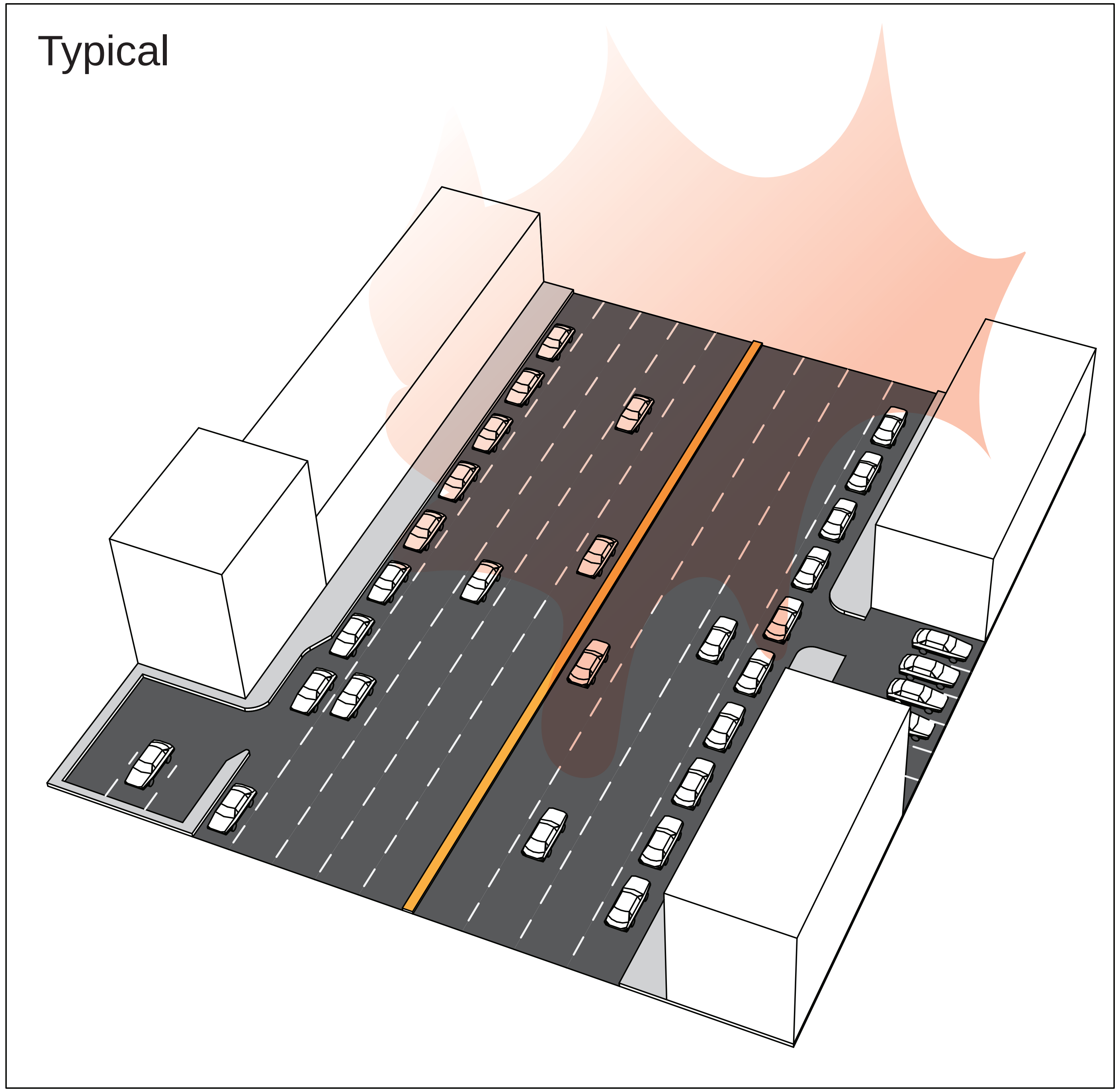


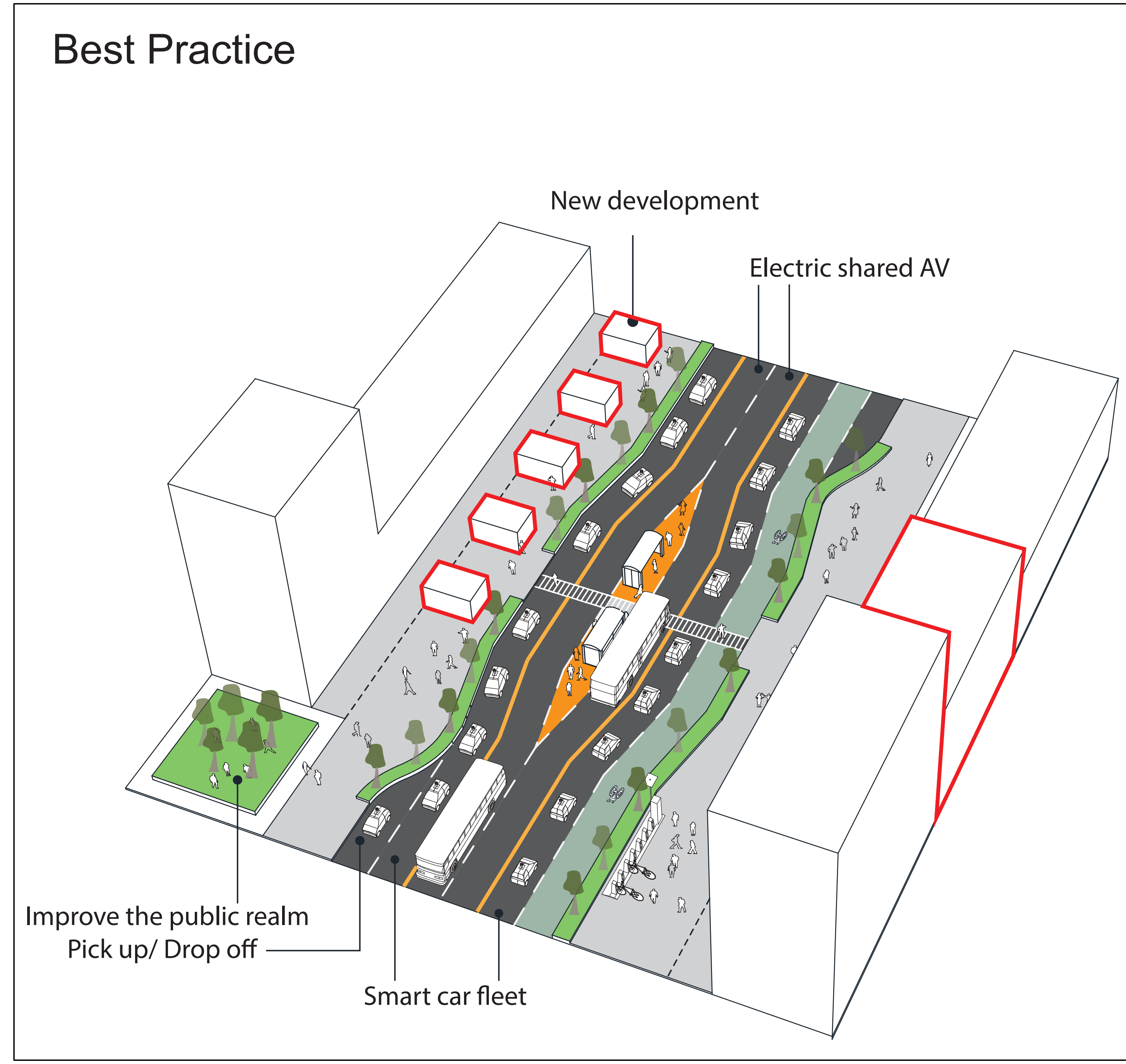


Urban waste heat and GHG emissions from infrastructure increase the urban heat island effect. In Tokyo, waste heat resulting from air conditioners and human activities can increase air temperature by 1-2°C on weekdays in office districts (Kanda area and Nihonbashi) in summer. (Ohashi 2007)

Urban waste heat and GHG emissions from infrastructure can be reduced through improvements in the efficiency of urban systems. Waste heat can be recovered to produce energy or water. District cooling and on-site energy production also mitigate the urban heat island effect.

Transportation Efficiency

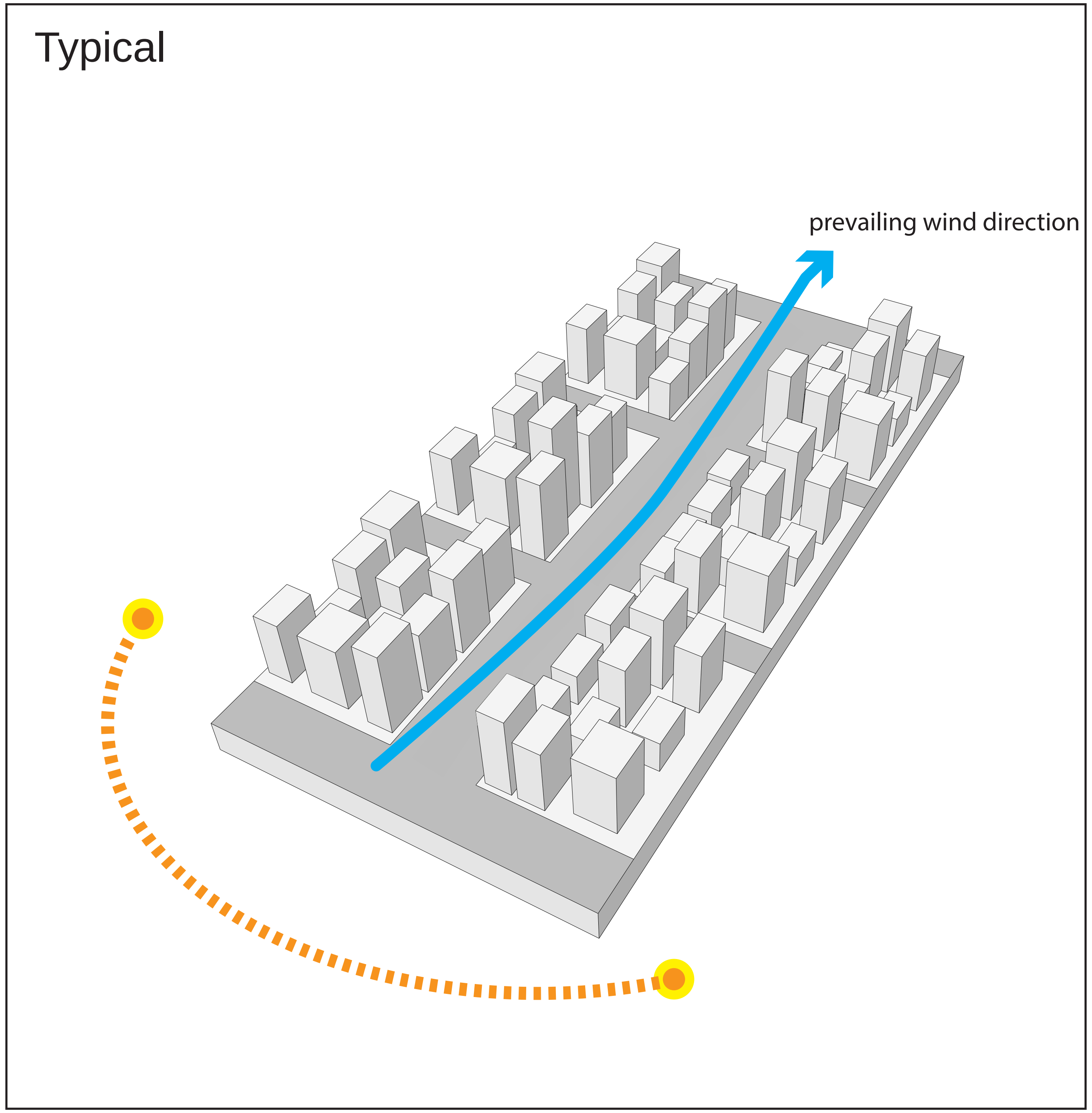




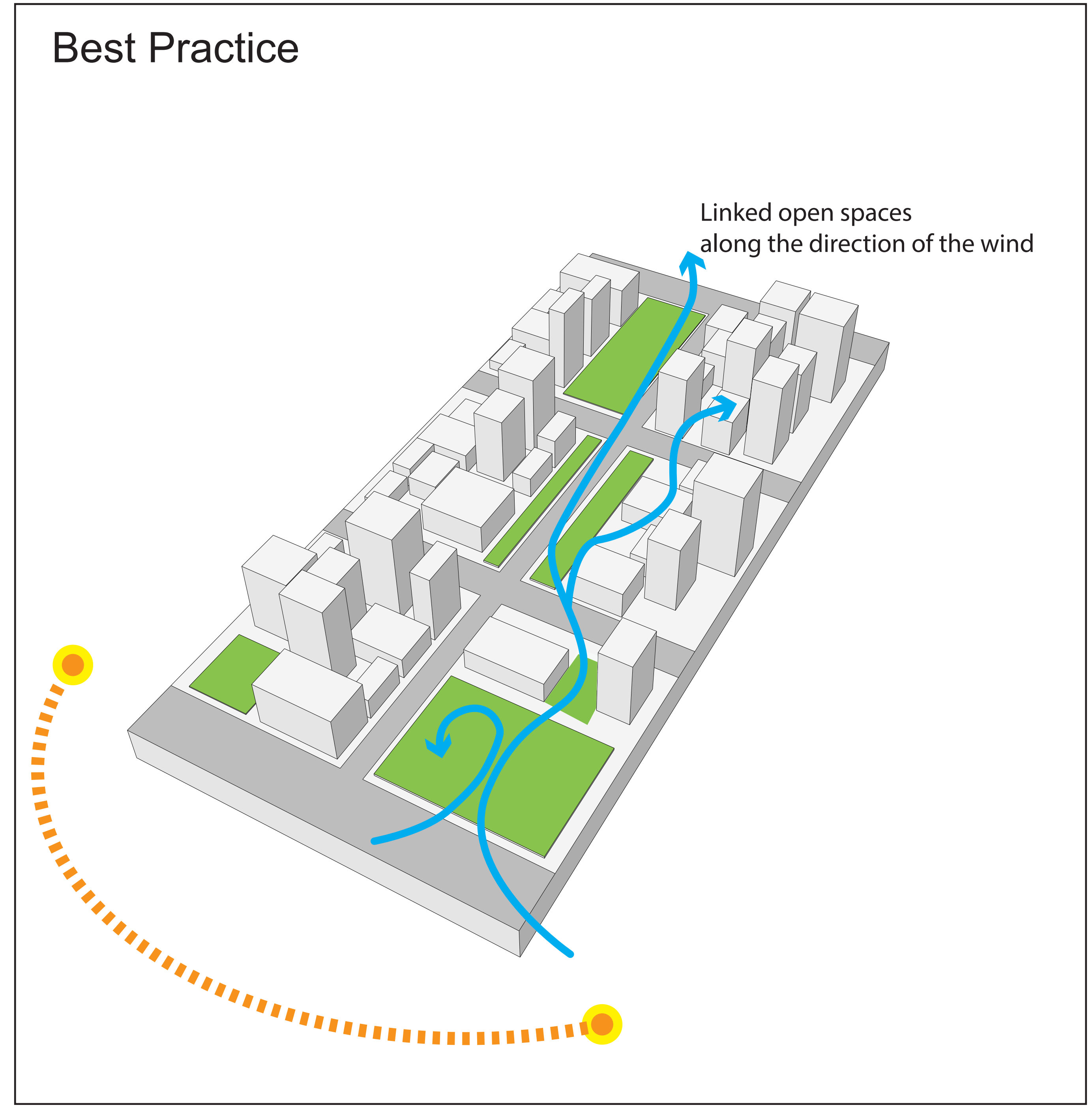
Over-reliance on fossil-fueled powered motor vehicles leads to significantly high waste heat emissions.
Inefficient single-occupancy vehicles increase impervious surfaces.

Compact urban districts with land use mix supporting mass transit and walkable streets reduce GHG emissions. This efficient land use allows for greater vegetation cover, which further reduces the urban heat island.

Wind Corridor

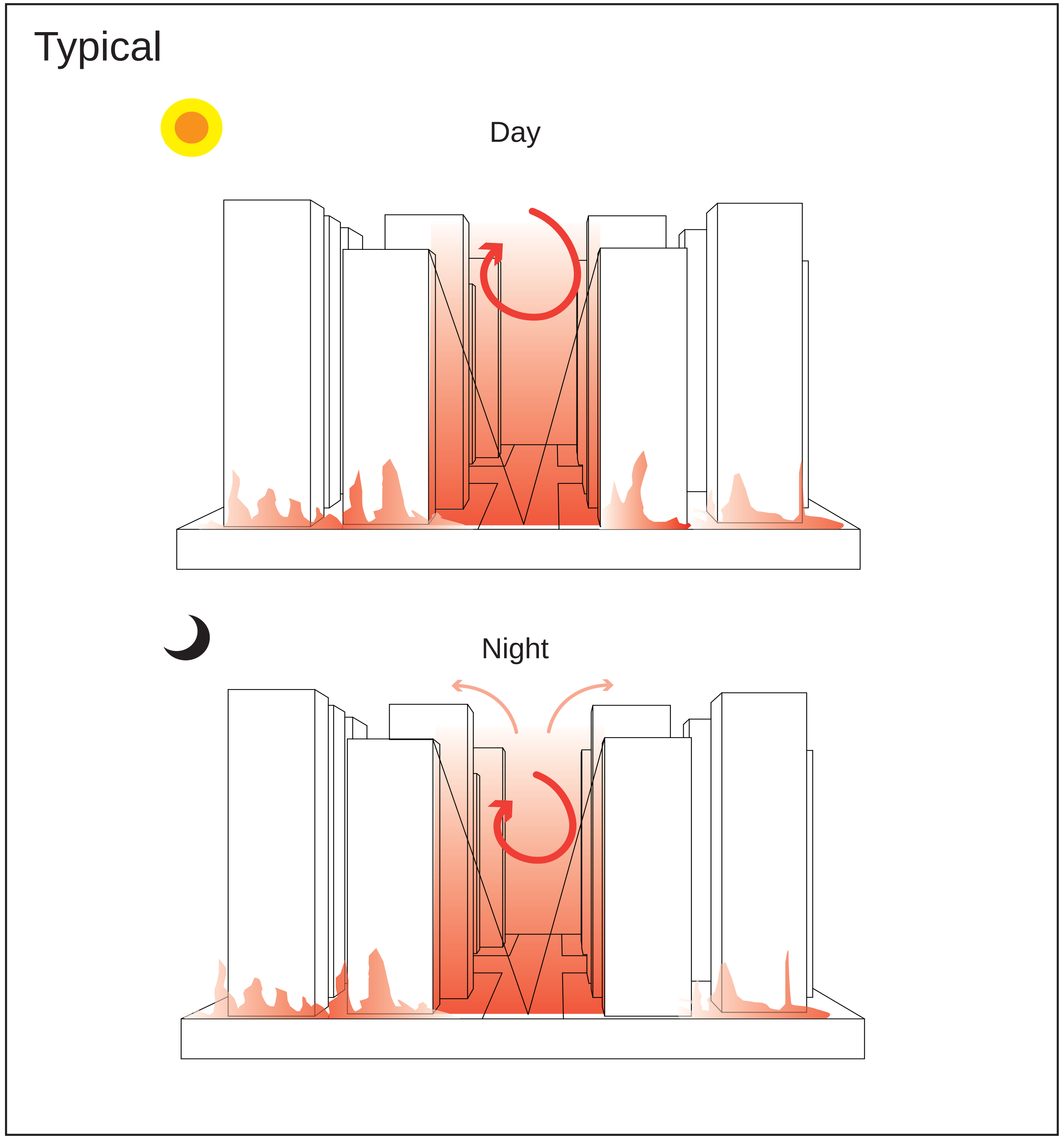


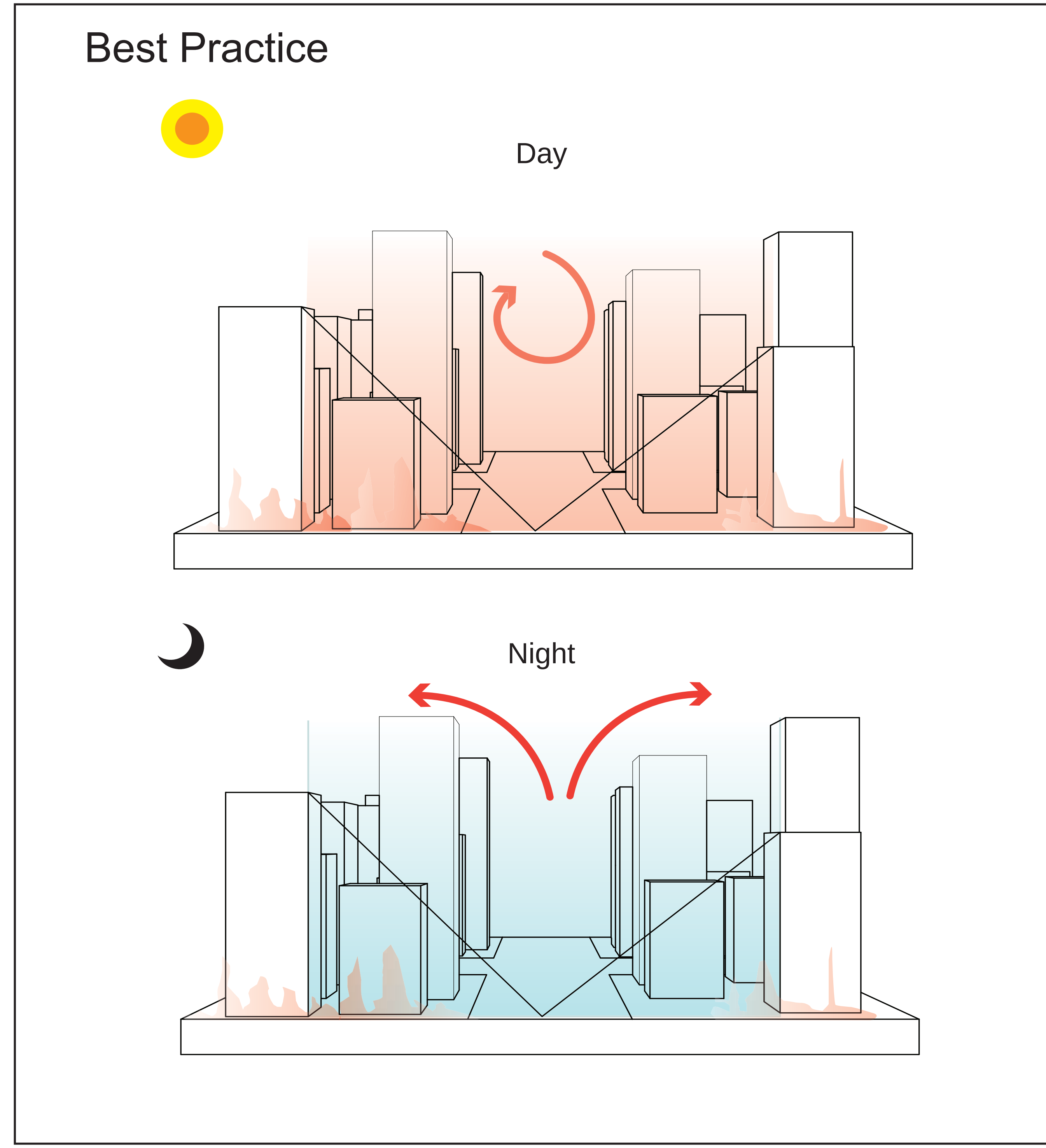
The configuration of buildings influences how wind moves through the city. With poorly-conceived configuration, the cooling summer breezes can be blocked or poorly distributed.



Strategically-aligned green infrastructure, varied building shapes and dedicated summer breeze corridors enhance passive cooling.

Sky View Factor

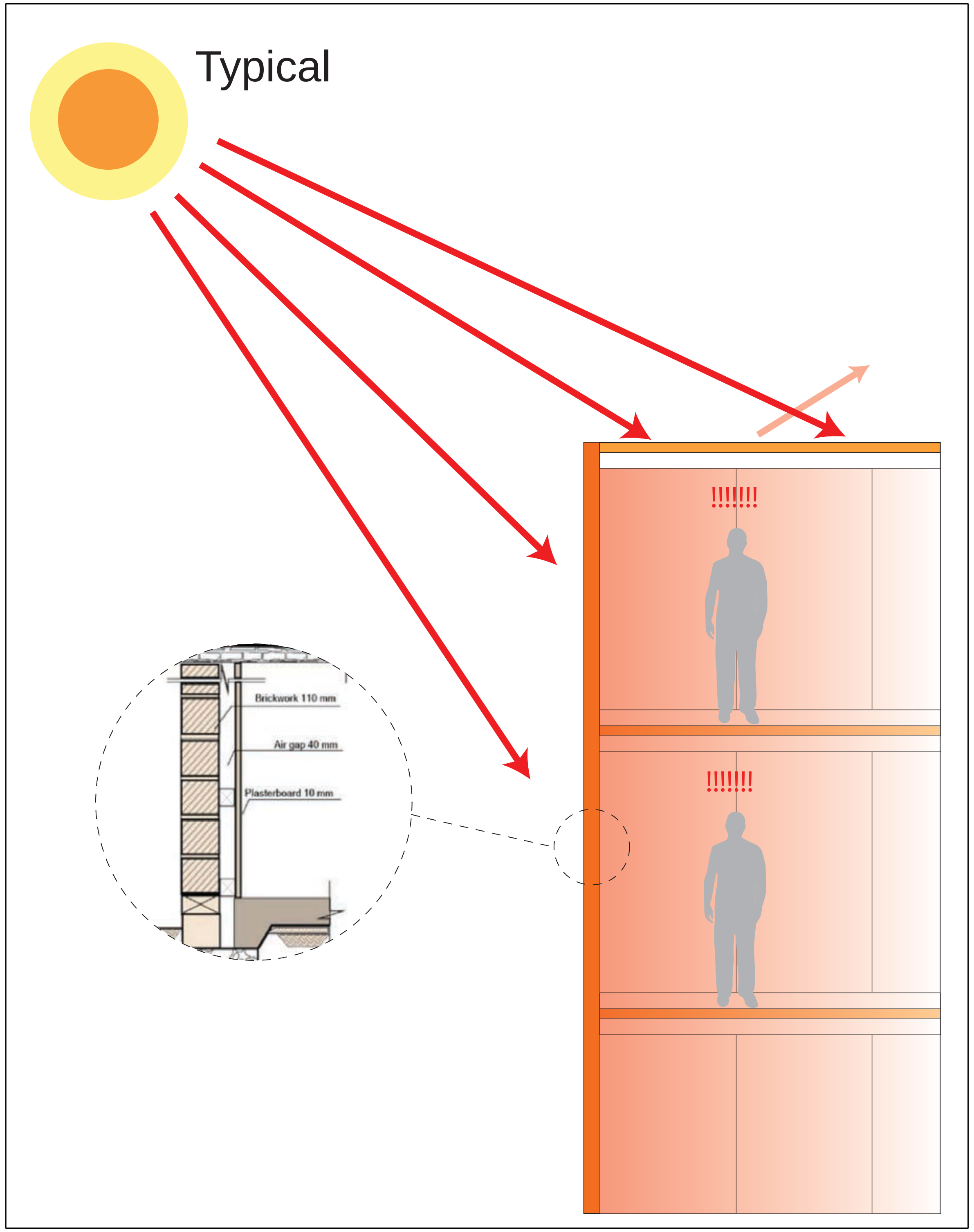


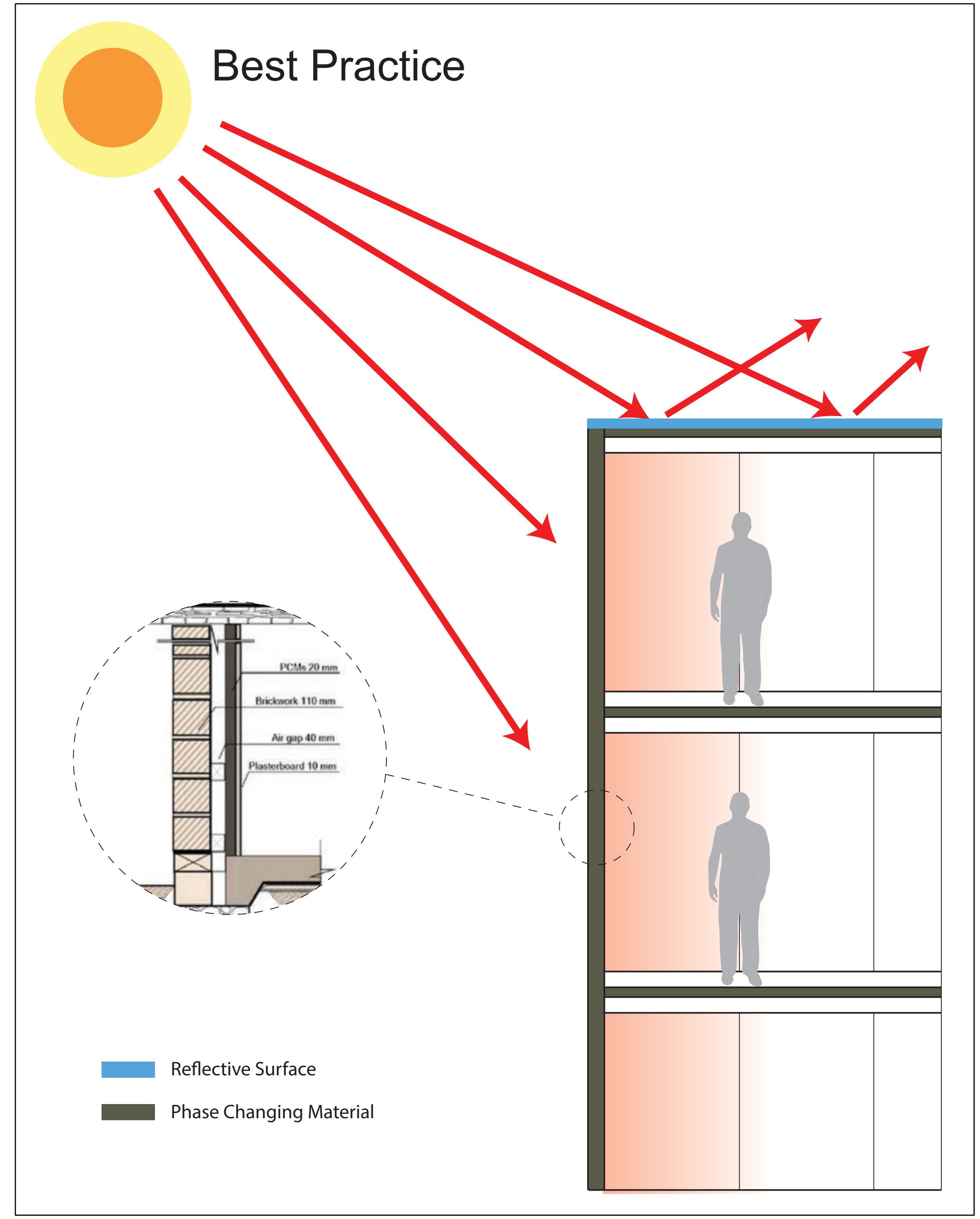


Solar radiation is absorbed by the city's hard surfaces during the day. Narrow urban canyons trap this heat from escaping into the cool night sky. The accumulation of this trapped heat creates dangerous urban heat conditions.

Varied building heights and massing can release more accumulated daytime heat into the night sky, cooling the district and reducing energy consumption.

Albedo & Phase Change Material

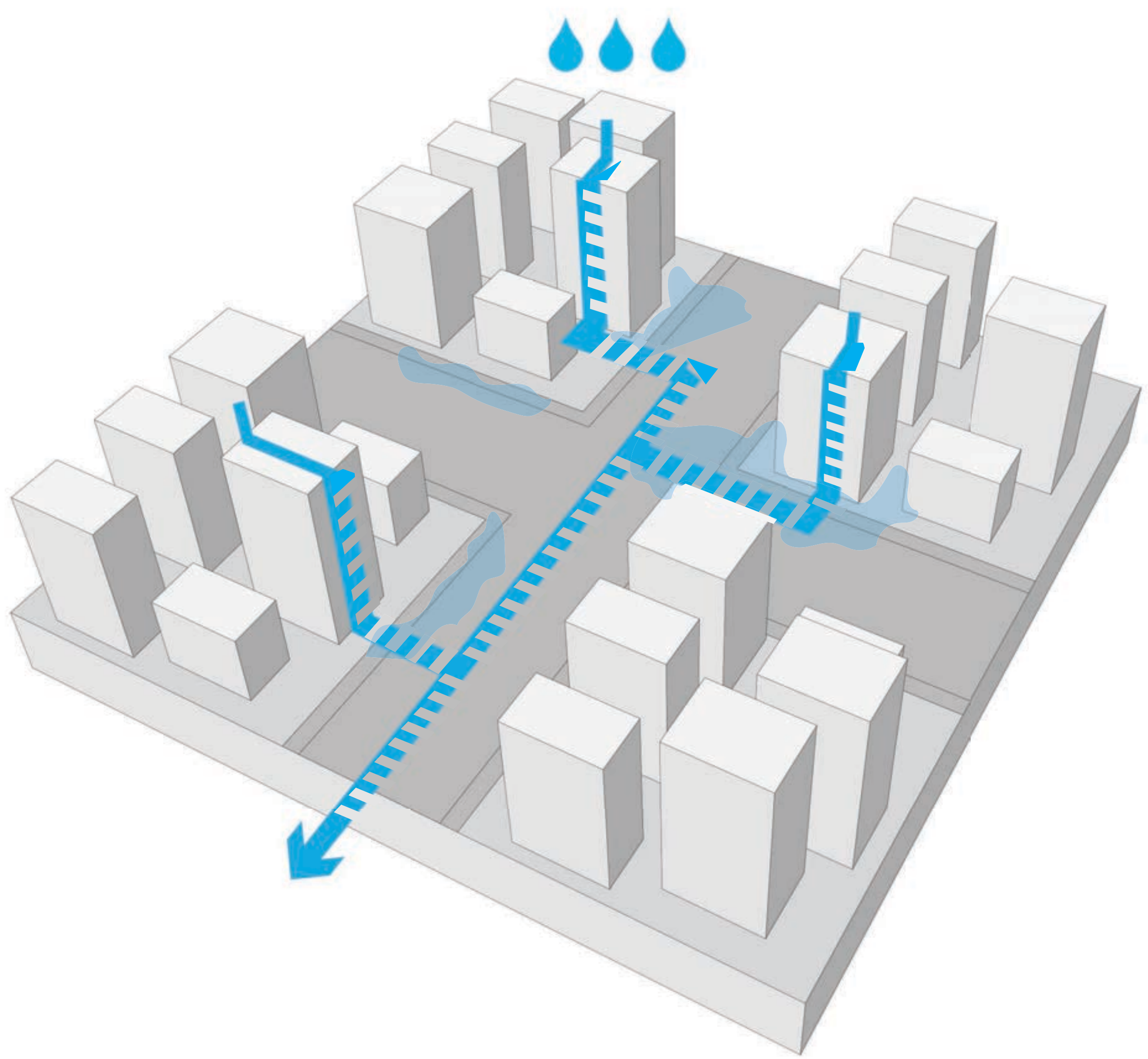




Phase change materials (PCM) used in buildings can melt and solidify within a range of 64-86ºF. They absorb heat during the day, reducing cooling loads. They release heat at night, when temperatures are lower.
PCM can help keep the interior temperature of the buildings at acceptable comfort levels during extreme heat and cold.

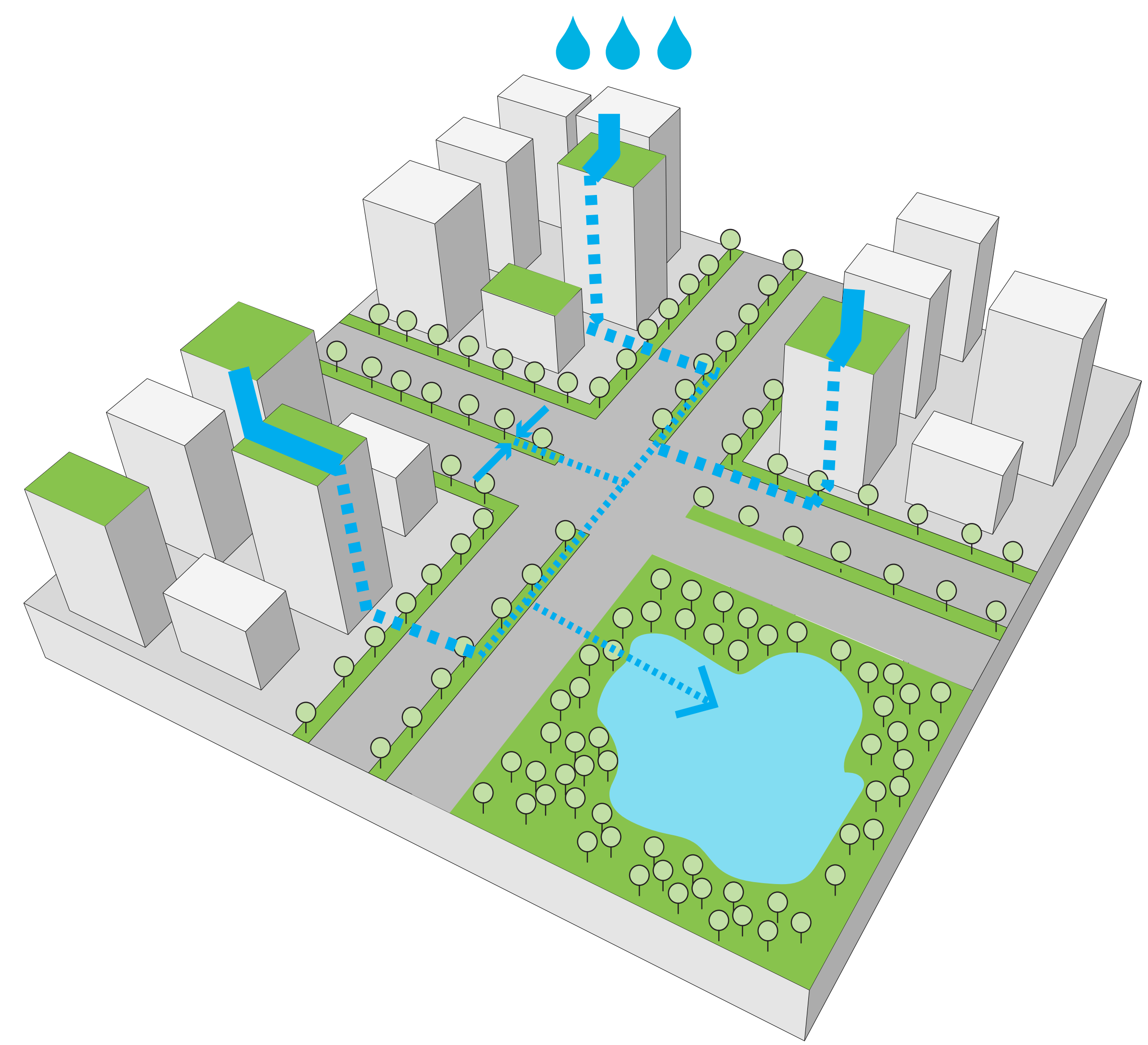
Stormwater Management

Typical



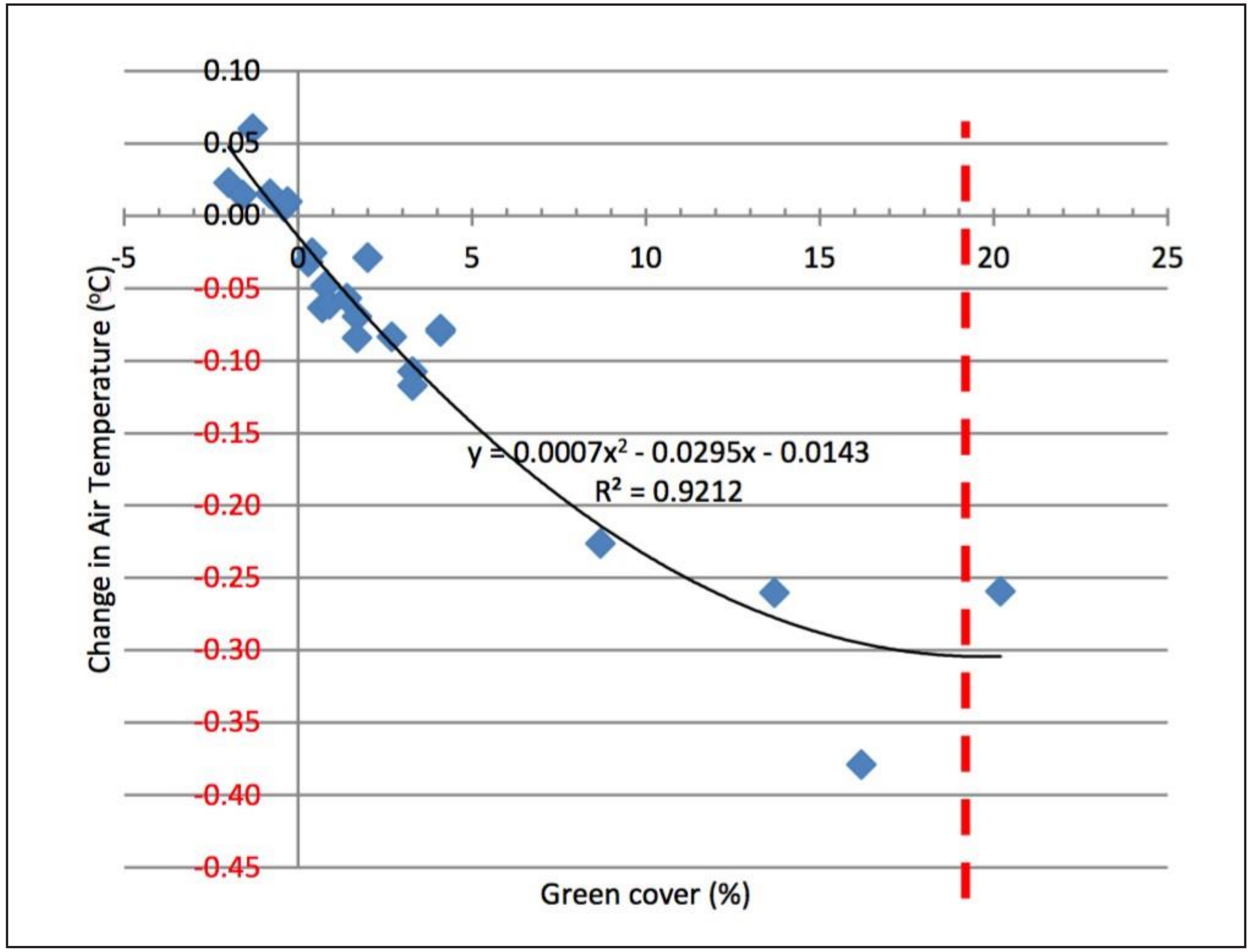
Lack of vegetative and tree canopy cover in a city raises temperatures and increases discomfort at the street level due to lack of shade. It also increases surface runoff during storm events; straining the capacity of water treatment infrastructure.

Best Practice



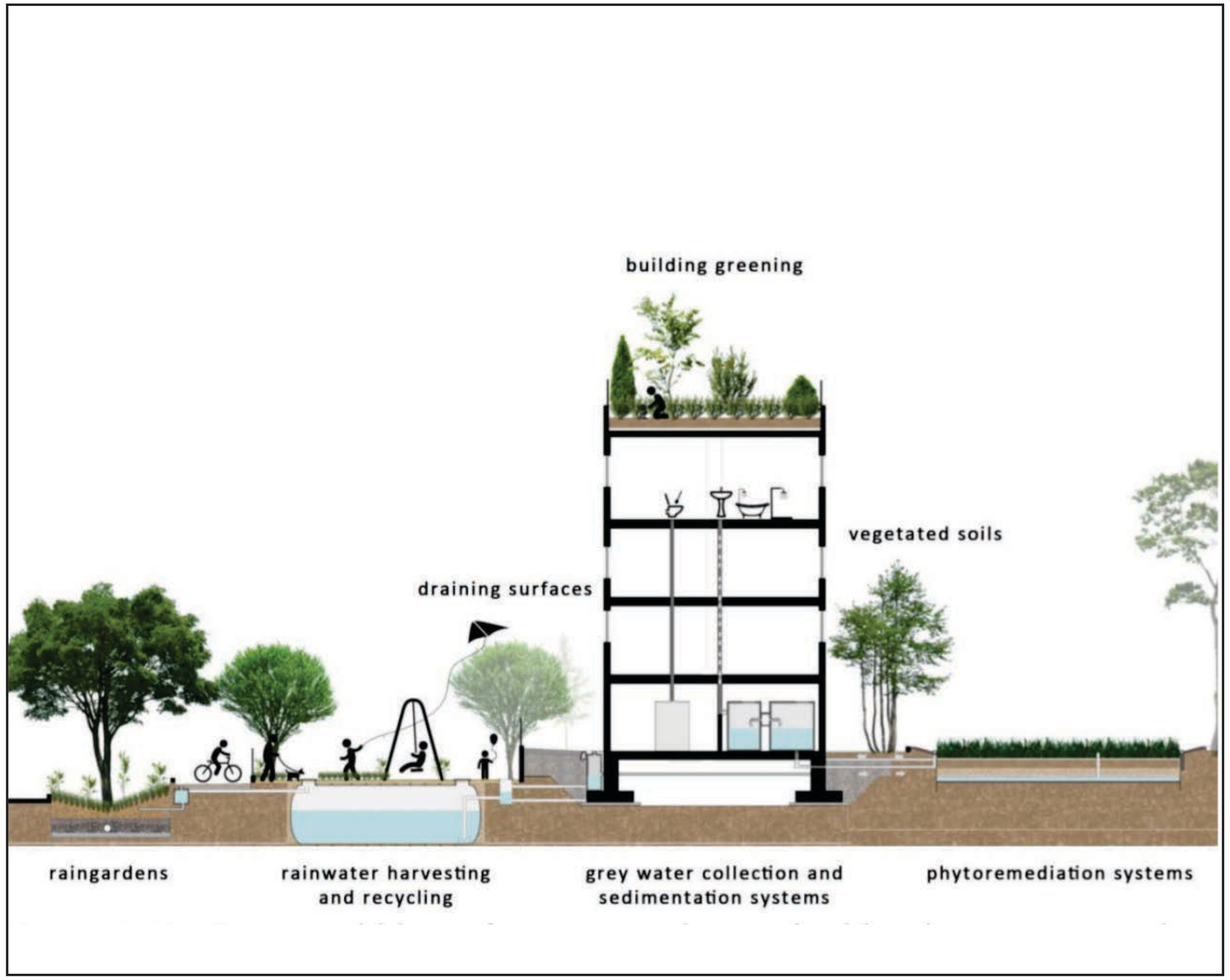
Increasing vegetative and tree canopy cover in cities can lower cooling demand in buildings and enhance comfort due to lower outdoor temperatures. It also reduces air pollution, surface runoff, and sequesters carbon.

Cooling Effect of Vegetation
Case Study



Summer daytime temperature and green cover, Glasgow, Rohinton Emmanuel

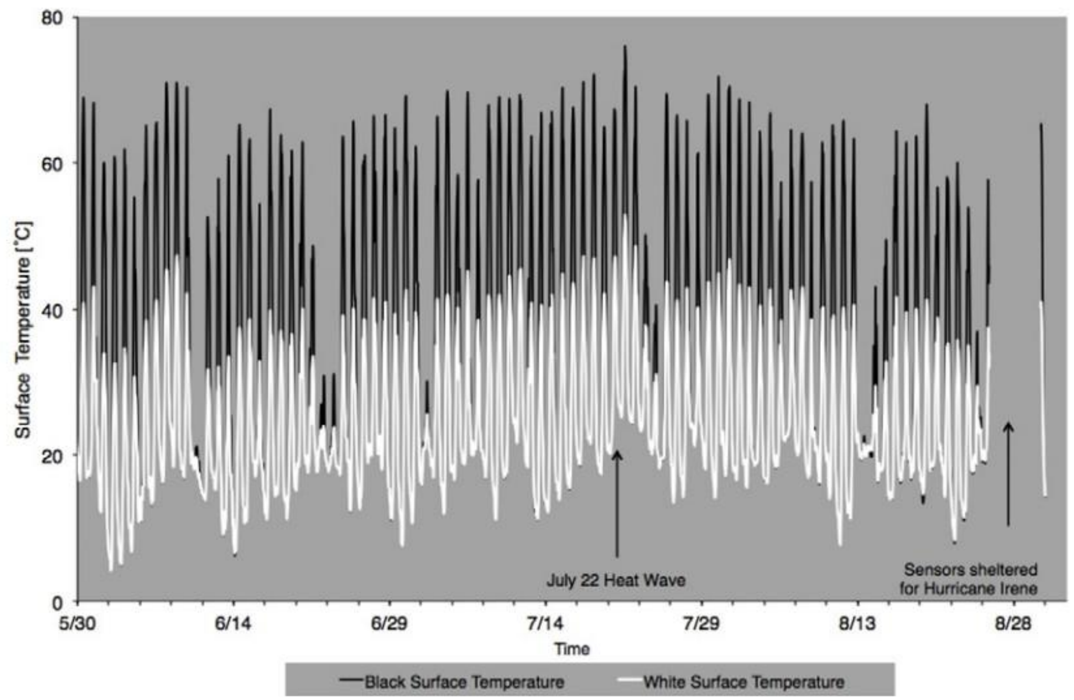
Summer daytime temperature in context of varied green cover



Green and blue infrastructure design: Napoli, Italy. Cristina Visconti and Mattia Leone

Evaporative cooling due to vegetated surfaces and tree canopy cover decreases building cooling load while enhancing pedestrian comfort.

Albedo Impact
Case Study



Surface temperature on a white and a black surface during summer 2011 in NYC

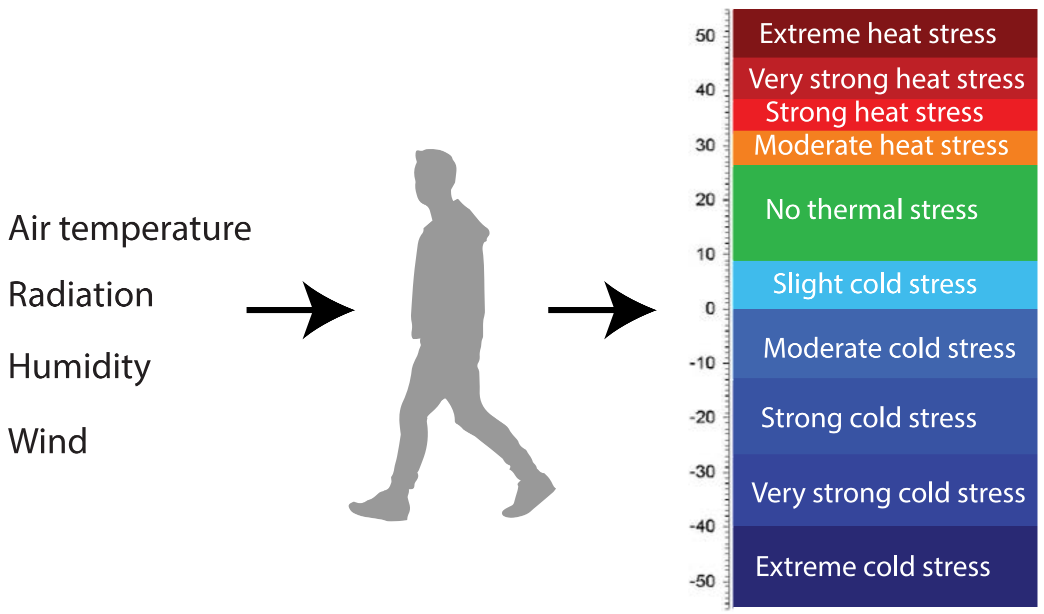
MoMA Queens summer 2011 (°C)	MoMA Queens 22 july 2011 (heat wave) (°C)
Avg Peak black temperature: 63.3	Peak black temperature: 76.5
Avg Peak white temperature: 39.7	Peak white temperature: 53.1
Avg B and W peak temp diff: 23.6	B and W temp diff: 23.4
Avg B and W temp diff: 6.6	Avg B and W temp diff: 8.6

Gaffin, Imhoff, Rosenzweig 2012

This experience in Queens, NYC, shows the influence of albedo on summer surface temperature.
Average surface albedos in U.S cities tend to range from 0.10 to 0.20. Albedos of 0.6 to 0.8 can be achieved with cool roofing and paving materials.

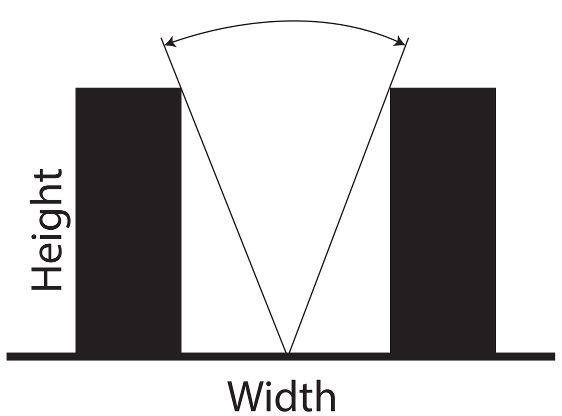
Analytical Criteria

Universal Thermal Climate Index (UTCI)



UTCI provides an assessment of a felt temperature based on human response to the outdoor thermal environment. It considers air temperature, wind speed, solar radiation and water vapor pressure.

Sky View Factor (SVF)



Sky view factor is calculated as the fraction of sky visible from the ground in a dense urban environment. Sky view factor is a dimensionless value that ranges from 0 to 1 with 0 being a fully obstructed sky and 1 a fully visible sky.

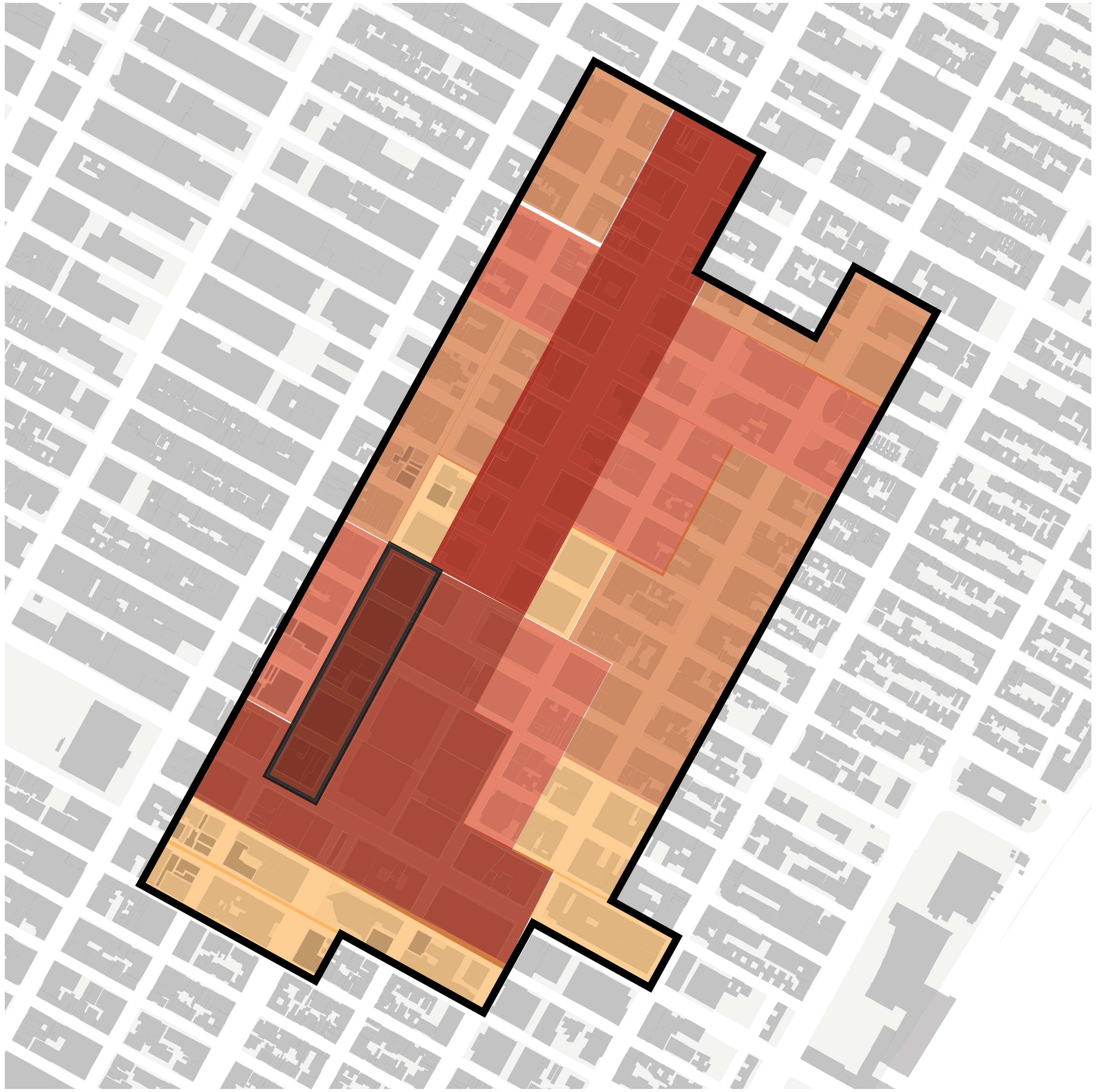
As a precedent, the city of Denver has a minimum of 15% of sky view factor as planning bylaw.

Urban Context

- 250,000 jobs
- One of the highest-profile business addresses in the world
- 60 million square feet of office space

The purpose of the rezoning is to ensure the area’s future as a world-class business district and major job generator for New York City and that East Midtown’s commercial office space remains attractive to a broad range of businesses, including major corporate tenants.

Floor Area Ratio



FAR (Floor Area Ratio)

- 21.6
- 18.0
- 23.0 (Transit Improvement Zone)
- 25.0
- 27.0 (Transit Improvement Zone)
- 30.0 (Vanderbilt Corridor)
- Proposed Greater East Midtown Rezoning Boundary

With the East Midtown rezoning proposal, the area will grow vertically, with the increasing FAR (Floor Area Ratio).

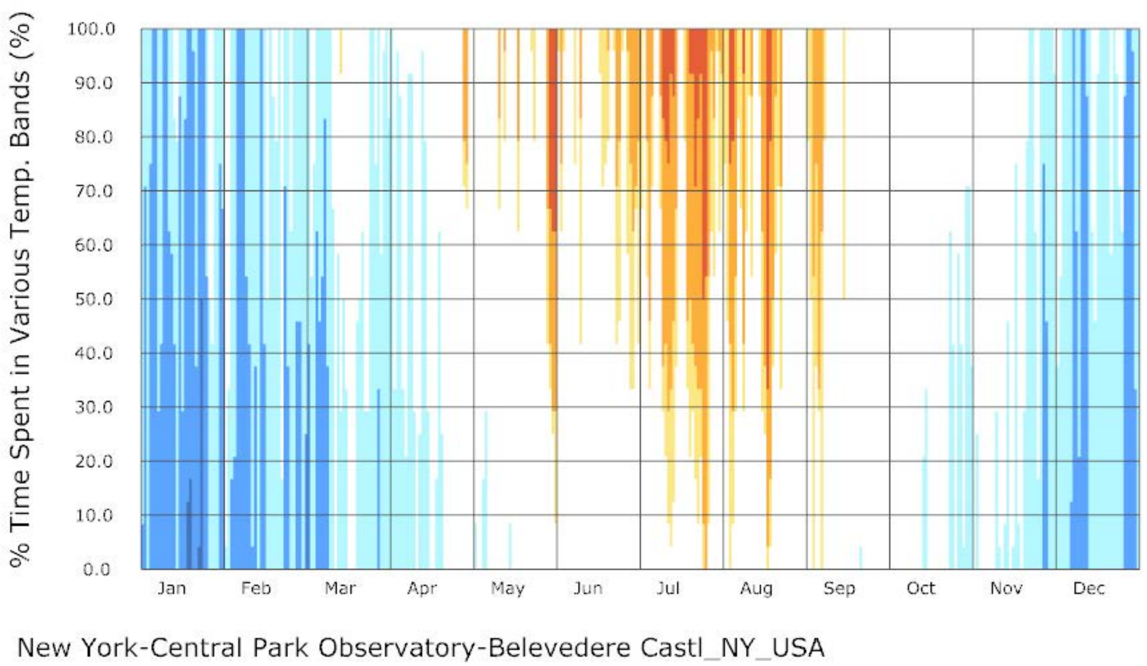
This can decrease available open space for public realm and increase the urban heat island effect, causing public health issues.

Source: The Municipal Art Society of New York

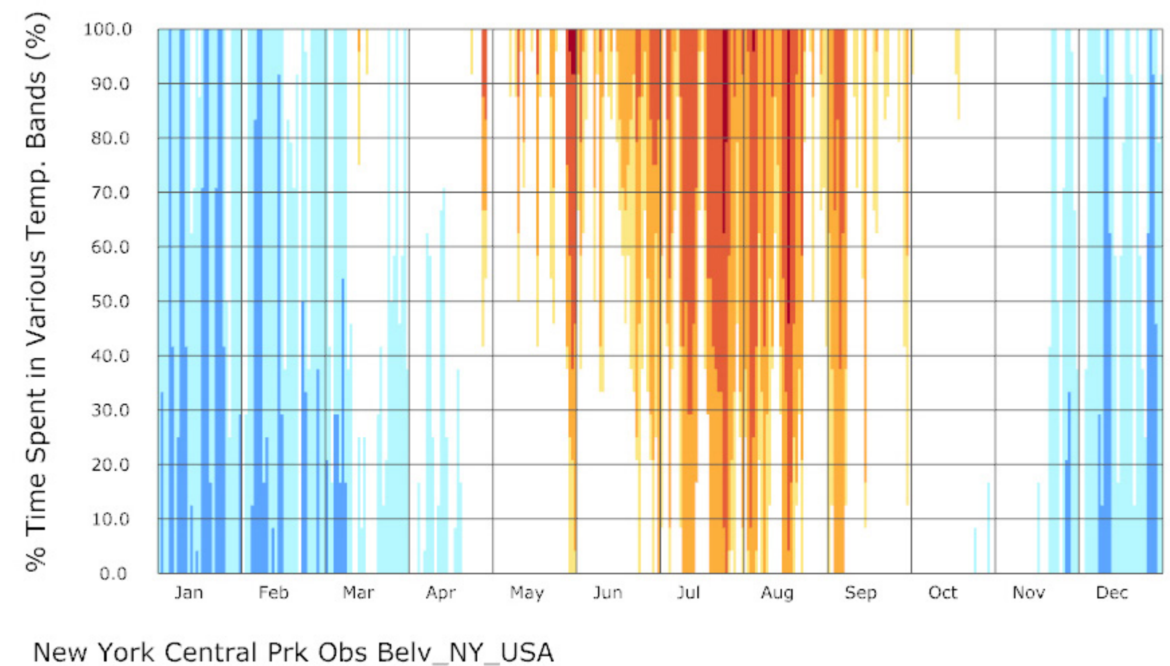
Climate Context

Baseline Central Park

2017



2050



Weather data comes from Central Park weather station. Projections for 2050 are based on IPCC (Intergovernamental Panel on Climate Change) model, based on a mid-range scenario, using the Climate Change world weather file generator.

These graphs show the pedestrian’s thermal comfort in Central Park, through the years 2017 and 2050.

Climate change will increase the number of days and nights of extreme heat stress in NYC, and in East Midtown in particular. This will increase residents' discomfort and cause health issues and more heat-related deaths during summer.

- >38°C: Extreme Heat Stress
- 32°C to 38°C: Strong Heat Stress
- 28°C to 32°C: Moderate Heat Stress
- 26°C to 28°C: Slight Heat Stress
- 9°C to 26°C: No Thermal Stress (Comfortable)
- 0°C to 9°C: Slight Cold Stress
- -13°C to 0°C: Moderate Cold Stress
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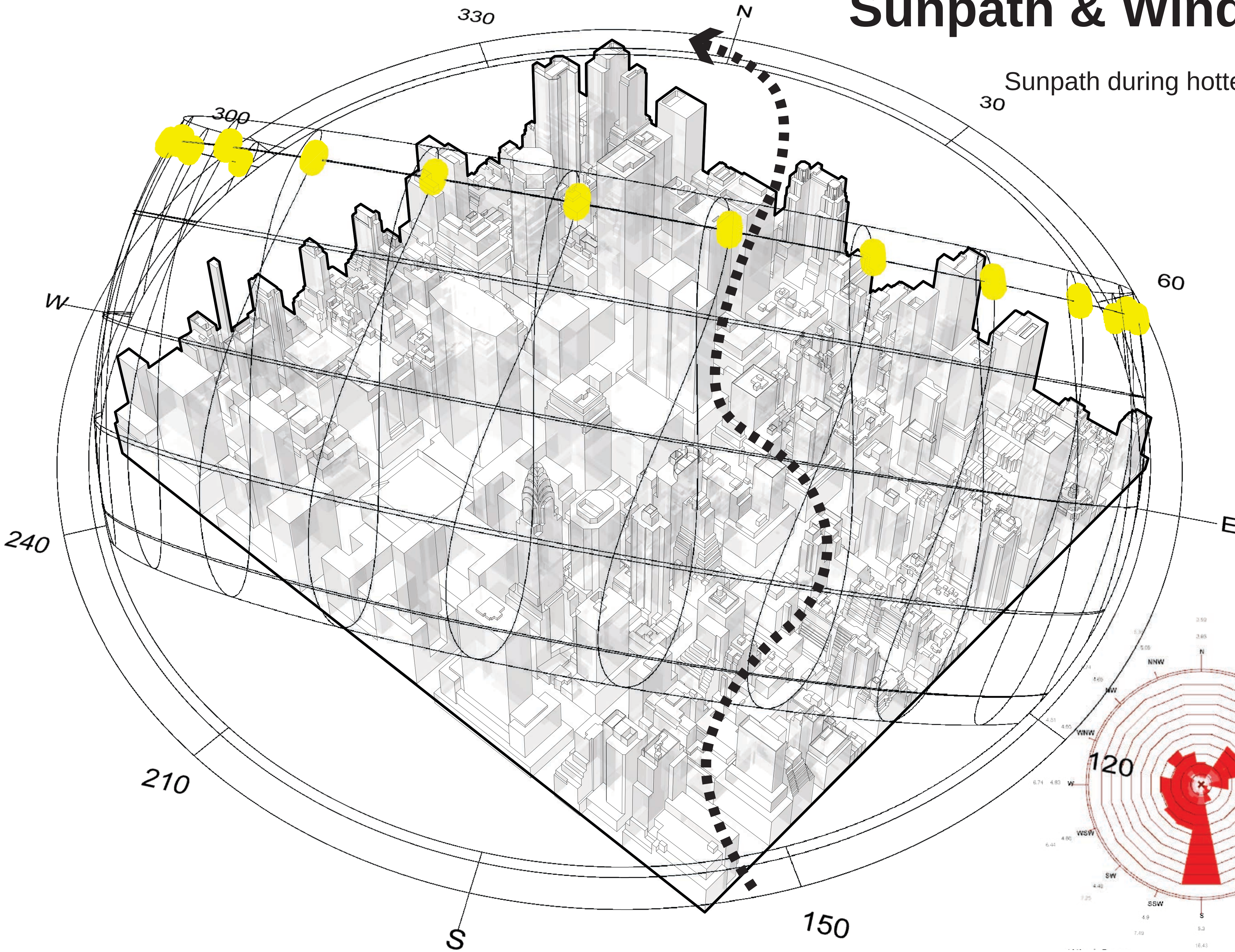
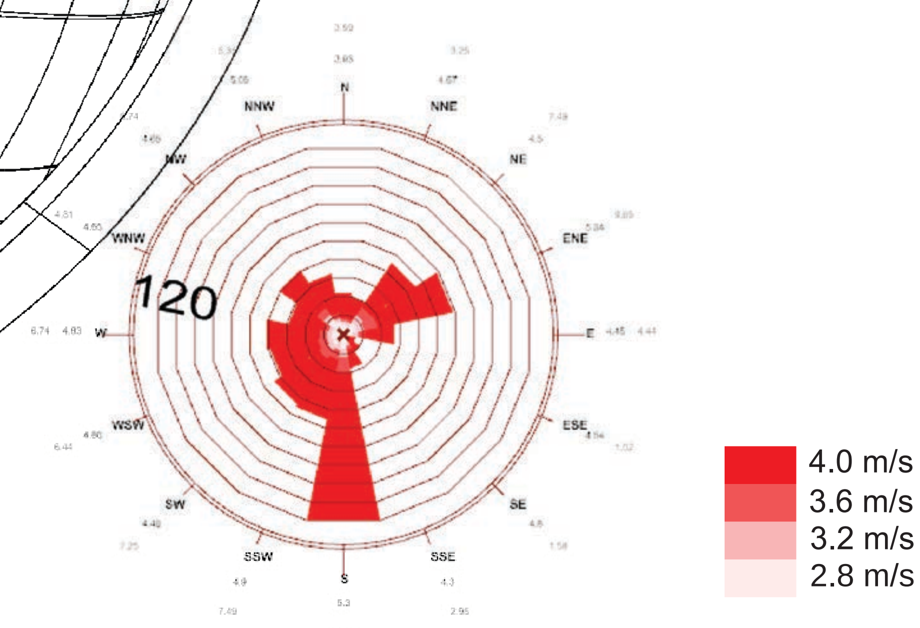
East Midtown

Sunpath & Wind Direction

Sunpath during hottest week in summer





Summer Wind

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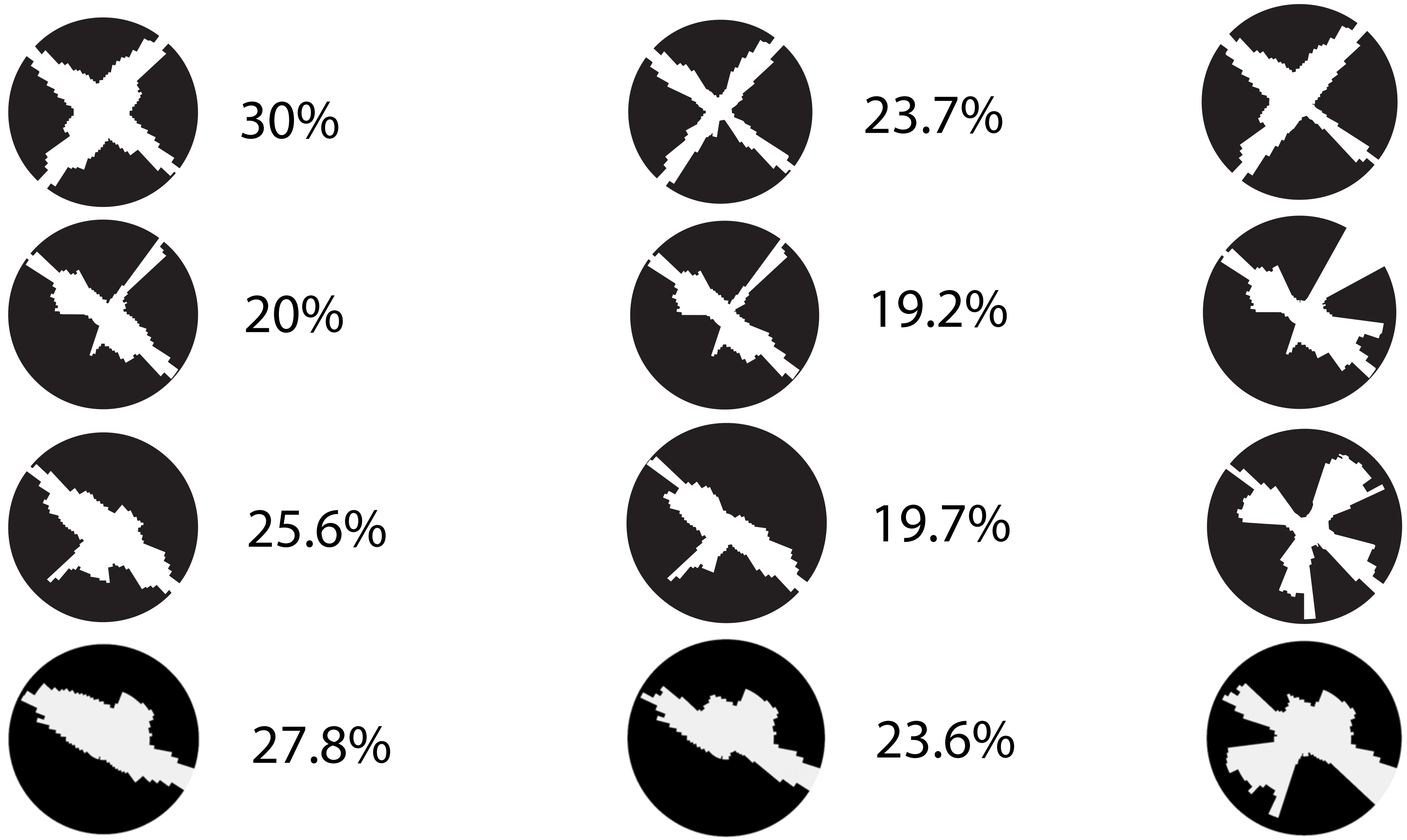
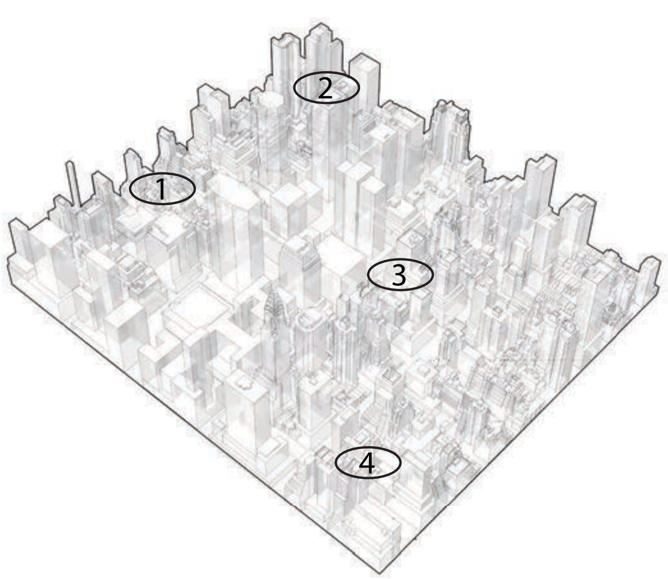
Sky View Factor

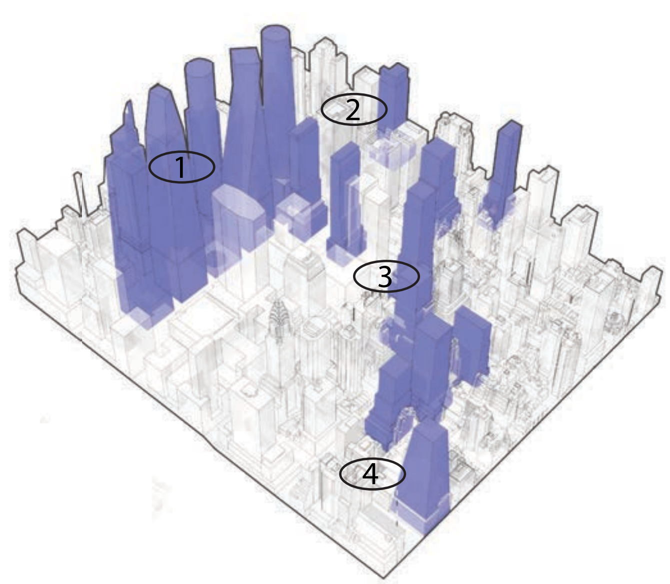
East Midtown



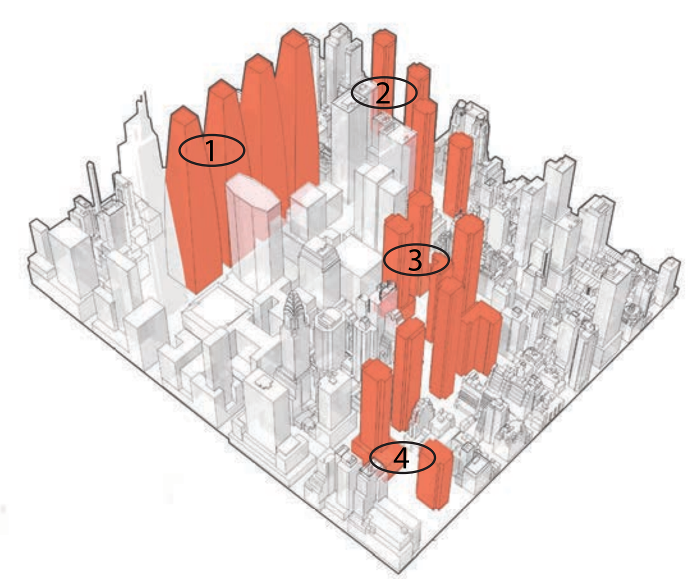
	Existing	Maximum FAR	Best Practice
1	30%	23.7%	28.1%
2	20%	19.2%	28.9%
3	25.6%	19.7%	29.1%
4	27.8%	23.6%	33.8%



Existing



Based on NYC Department of City Planning Maximum Build-Out Scenario



NYIT Urban Climate Lab proposal

According to different studies around the world, increasing sky view factor reduces urban heat island effect.

In East Midtown, maximum FAR scenario could increase maximum urban heat island intensity by 1.8°F, while best practice could reduce it by 1.44°F.

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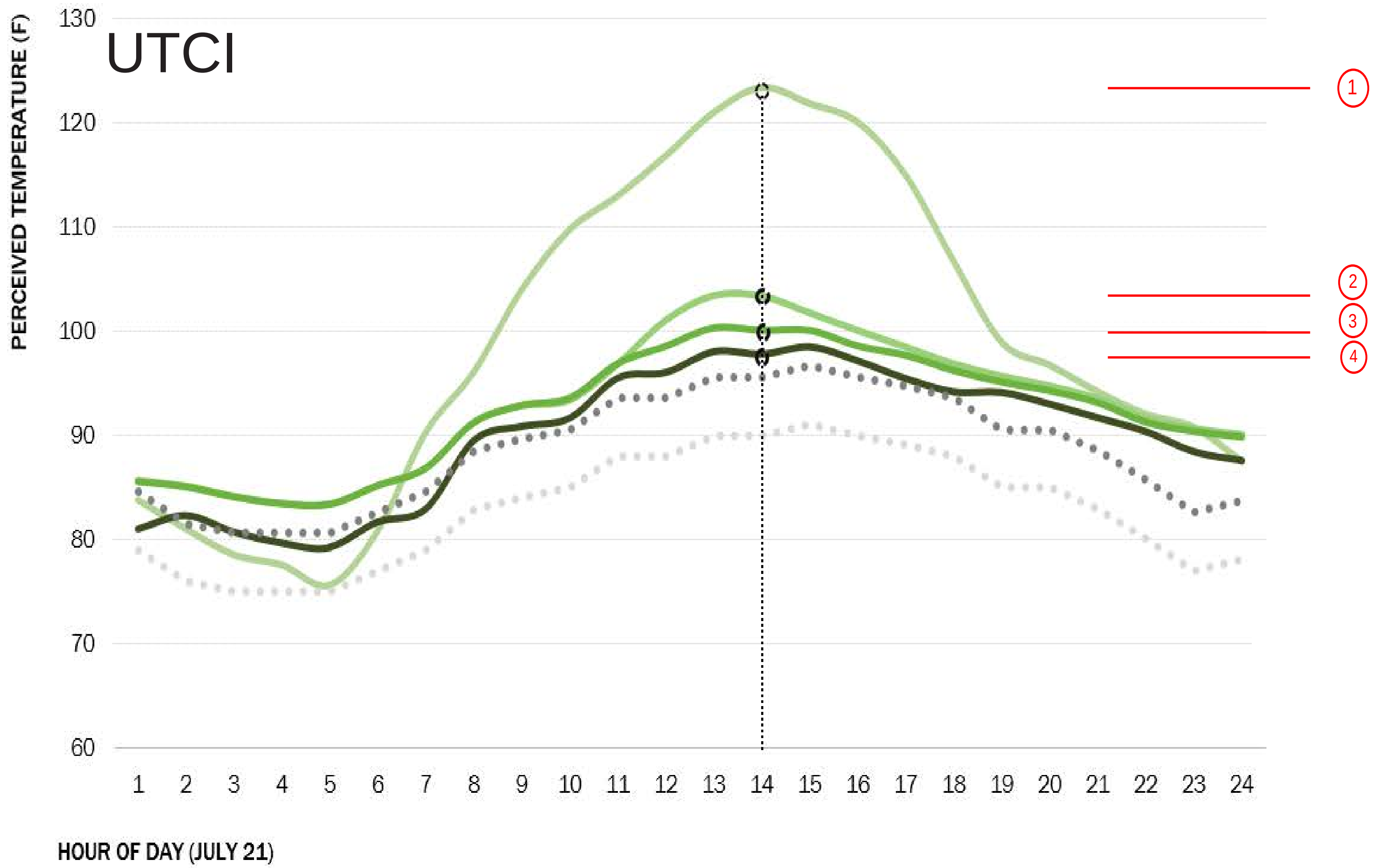
Outdoor Comfort

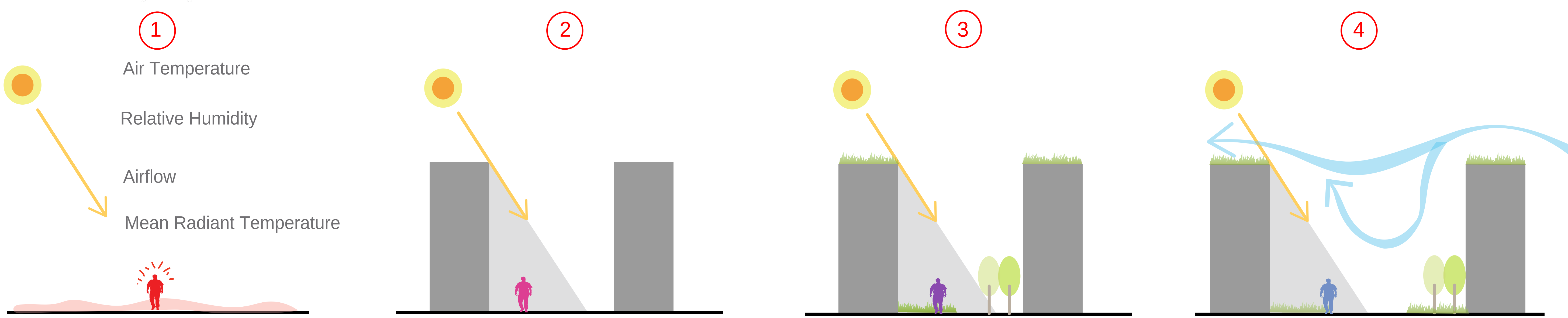
Projection: 21 July 2050



Design interventions: shading, increased airflow and vegetation have a huge impact on pedestrian thermal comfort.

1 In Sun (2050)
2 In Shade (2050)
3 Shade + Vegetation (2050)
4 Shade + Airflow (50%) (2050)
Air Temperature (2050)
Air Temperature (Current)

Michael Esposito, Atelier Ten



Outdoor Comfort (Unshaded)
Air Temperature: 96ºF
Feels Like (UTCI) Temperature: 123ºF

+ Shading
Air Temperature: 96ºF
Feels Like (UTCI) Temperature: 103ºF

+ Trees / Vegetation
Air Temperature: 96ºF
Feels Like (UTCI) Temperature: 100ºF

+ Airflow(2 m/s)
Air Temperature: 96ºF
Feels Like (UTCI) Temperature: 98ºF

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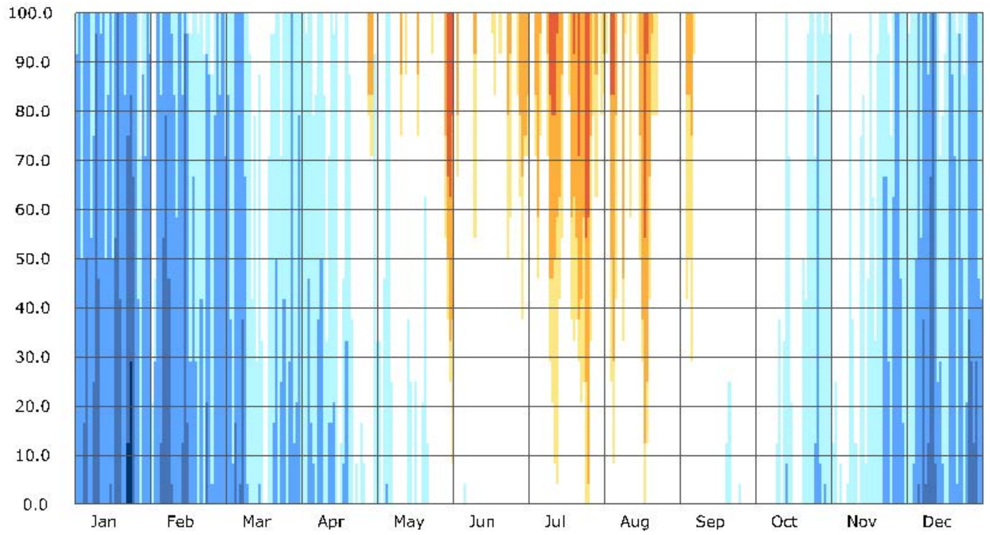
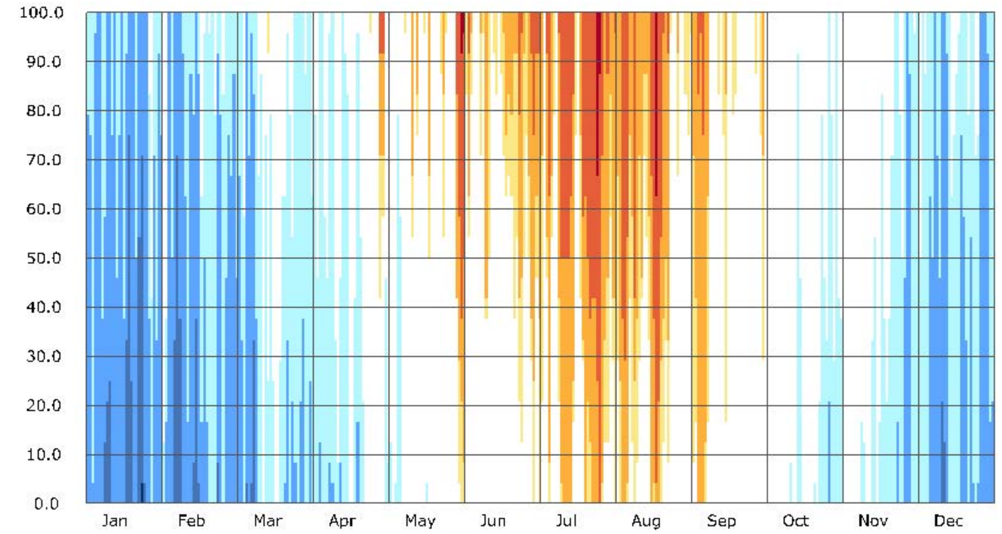
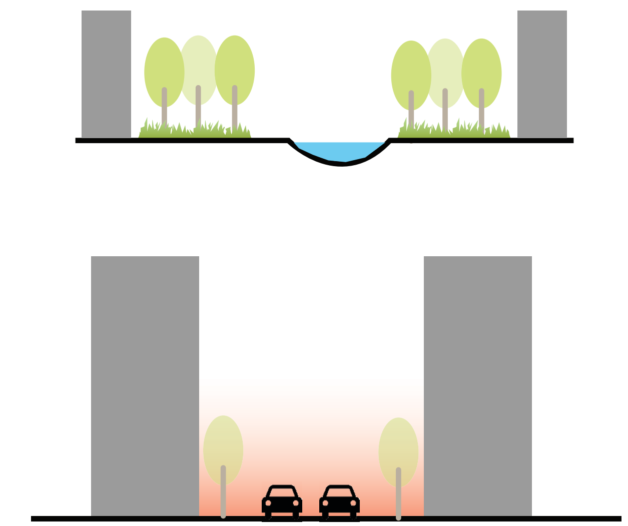
Worst Case Projection
UTCI Measurement



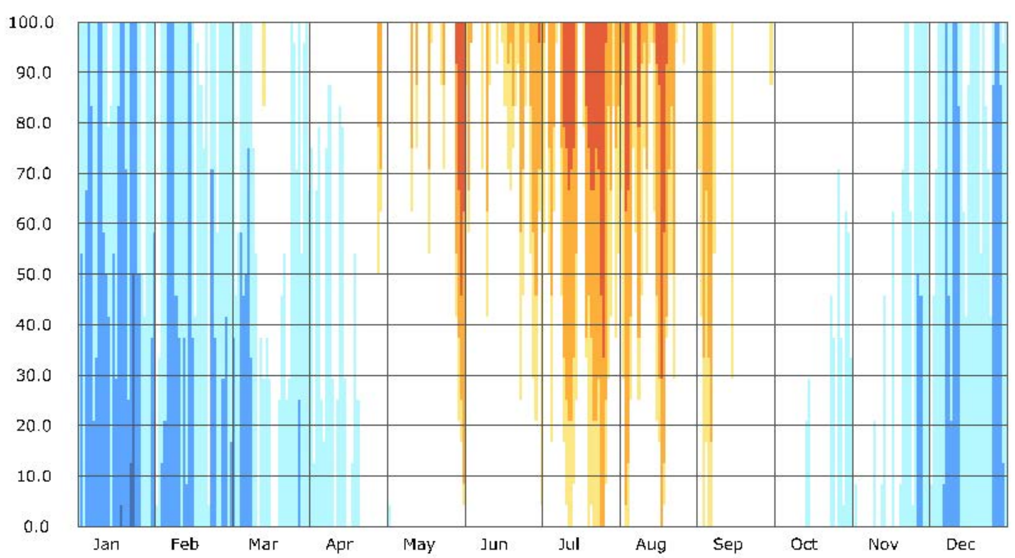
2017 Central Park
Time of cumulated heat stress: 30 days



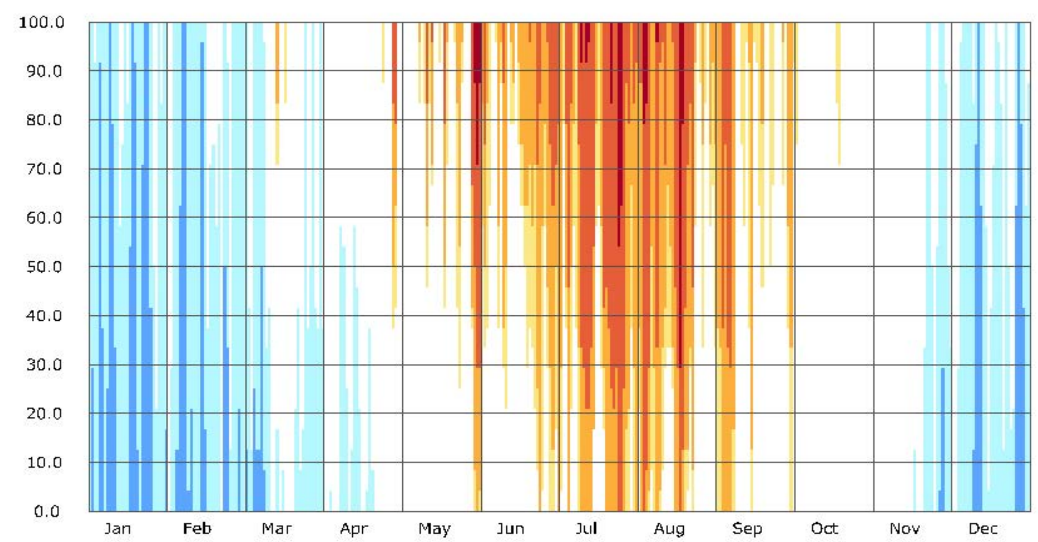
2050 Central Park
Time of cumulated heat stress: 66 days



This is the case of a street with a low sky view factor and low ventilation.



2017 East Midtown
Time of cumulated heat stress: 50 days



2050 East Midtown
Time of cumulated heat stress: 86 days

Projections:
- summer breeeze would be 80% lower than in central Park (Hong Kong, Chao and Ren)
- air temperature would be 1.8°F higher than Central Park (Eliasson 1996, Goteborg)

- >38°C: Extreme Heat Stress
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The projections for East Midtown are based on Central Park weather data (see page 15). They were obtained with evidence-based climate modifications which are characteristic of Central Business Districts and shown by case-studies

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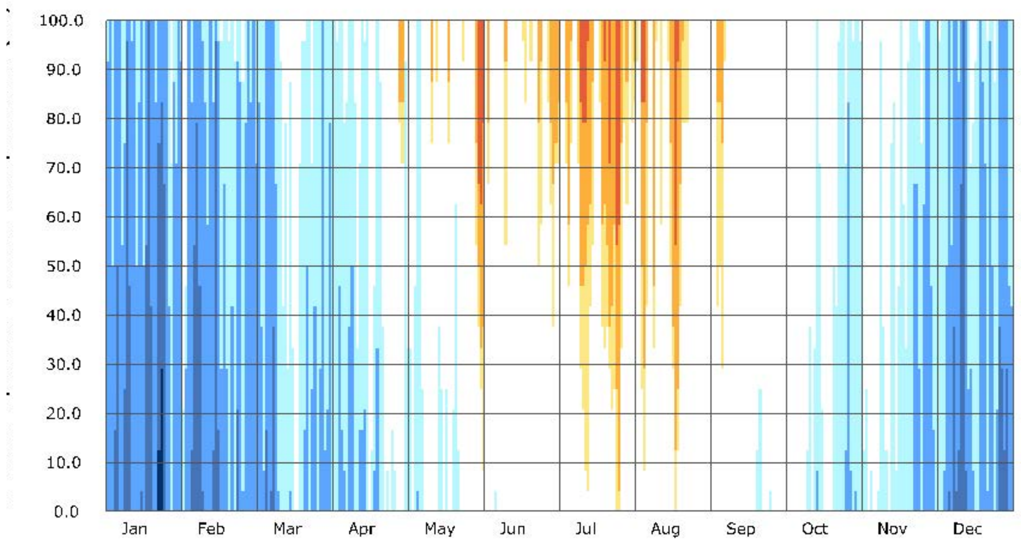
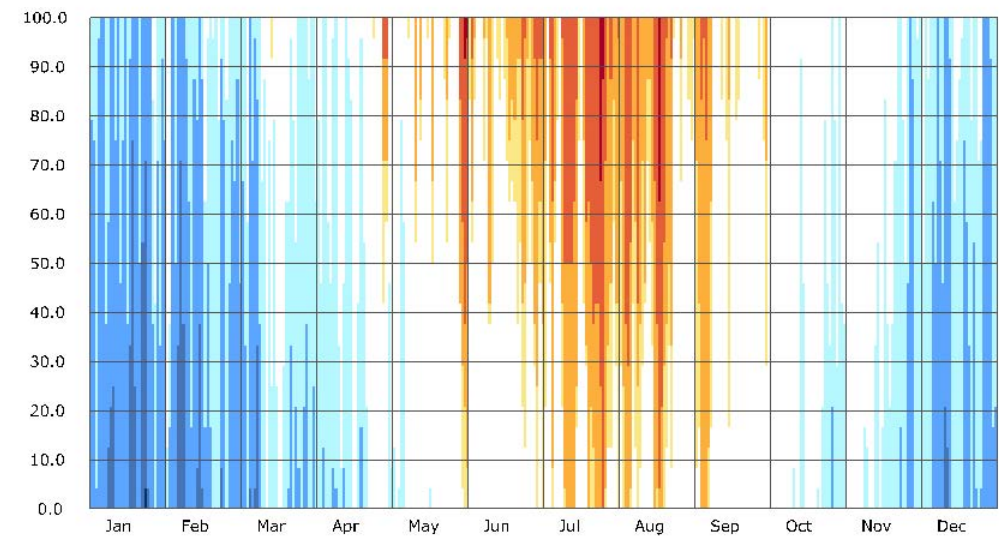
East Midtown

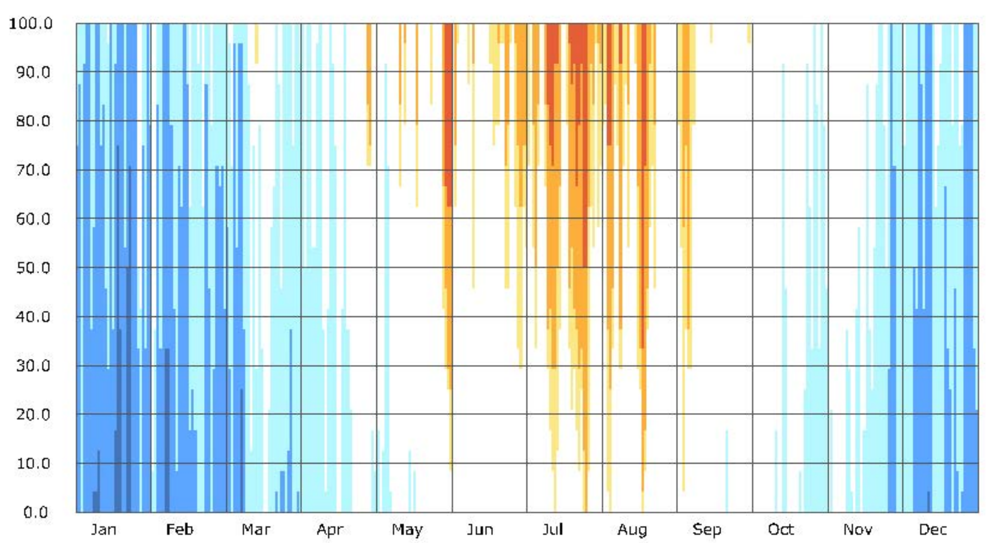
Best Case Projection
UTCI Measurement



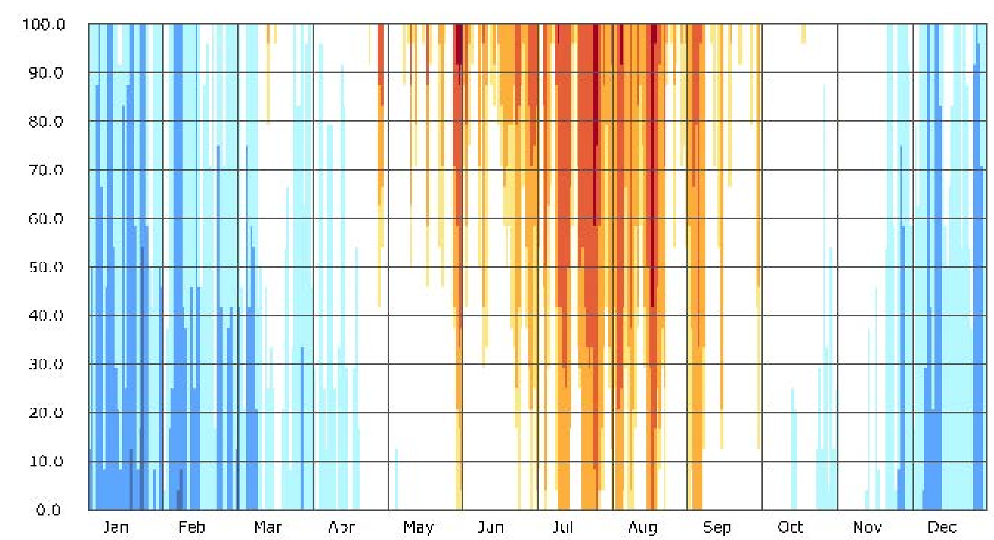
2017 Central Park
Time of cumulated heat stress: 30 days



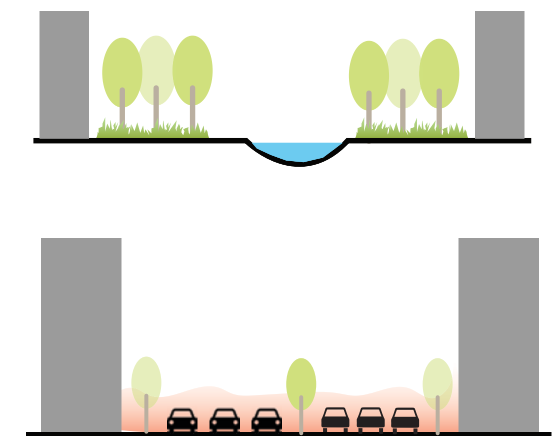
2050 Central Park
Time of cumulated heat stress: 66 days



2017 East Midtown
Time of cumulated heat stress: 39 days

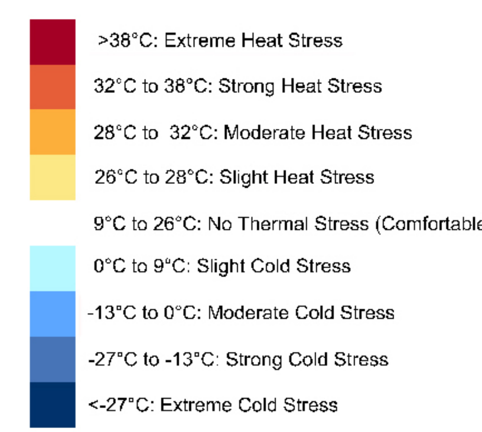


2050 East Midtown
Time of cumulated heat stress: 74 days



This is the case of a street with increased sky view factor, green cover and ventilation.

Projections:
-summer breeze would be only 40% lower than in Central Park (Hong Kong, Chao and Ren)
- air temperature would be 0.54°F higher than Central Park (Eliasson 1996, Goteborg)



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Privately Owned Public Spaces (POPS)

Vegetation Coverage

Green cover: 10% (16,885 m2) — Street trees: 6,400 m2; POPS: 10,485 m2

Average change in air temperature: -0.45 0F

Green cover: 20% (33,769 m2) — Street trees: 8,400 m2; POPS: 25,369 m2

Average change in air temperature: -0.58 0F

Changes in air temperature are to be compared to baseline temperature (2017). Based on case study in Glasgow, Rohinton Emmanuel (see References on page 27)

Vegetation Species

Pin Oak
Full sun,
street tree,
tolerant of flooding
and stormwater

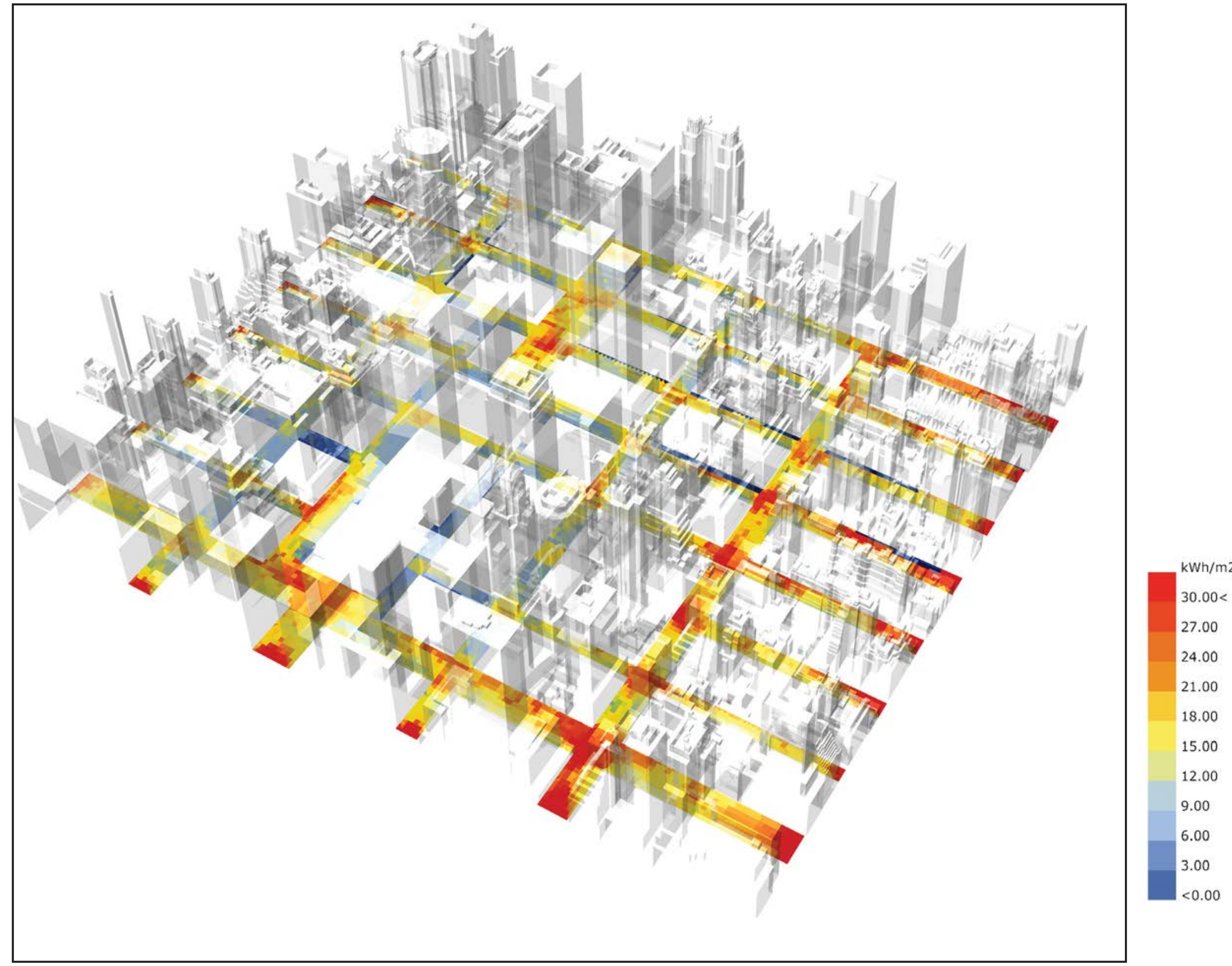
Northern Red Oak
Full sun,
need space,
large leaves,
tolerant of stormwater,
intolerant of flooding,
tolerant of pollution

Common Alder
Partial shade,
smaller leaves,
good street tree,
tolerant of poor soil,
flooding and drought

American Hophornbeam
Partial shade,
street tree,
slow grower

Based on Natural Resources Group, NYC Department of Parks and Recreation

Radiant Heat

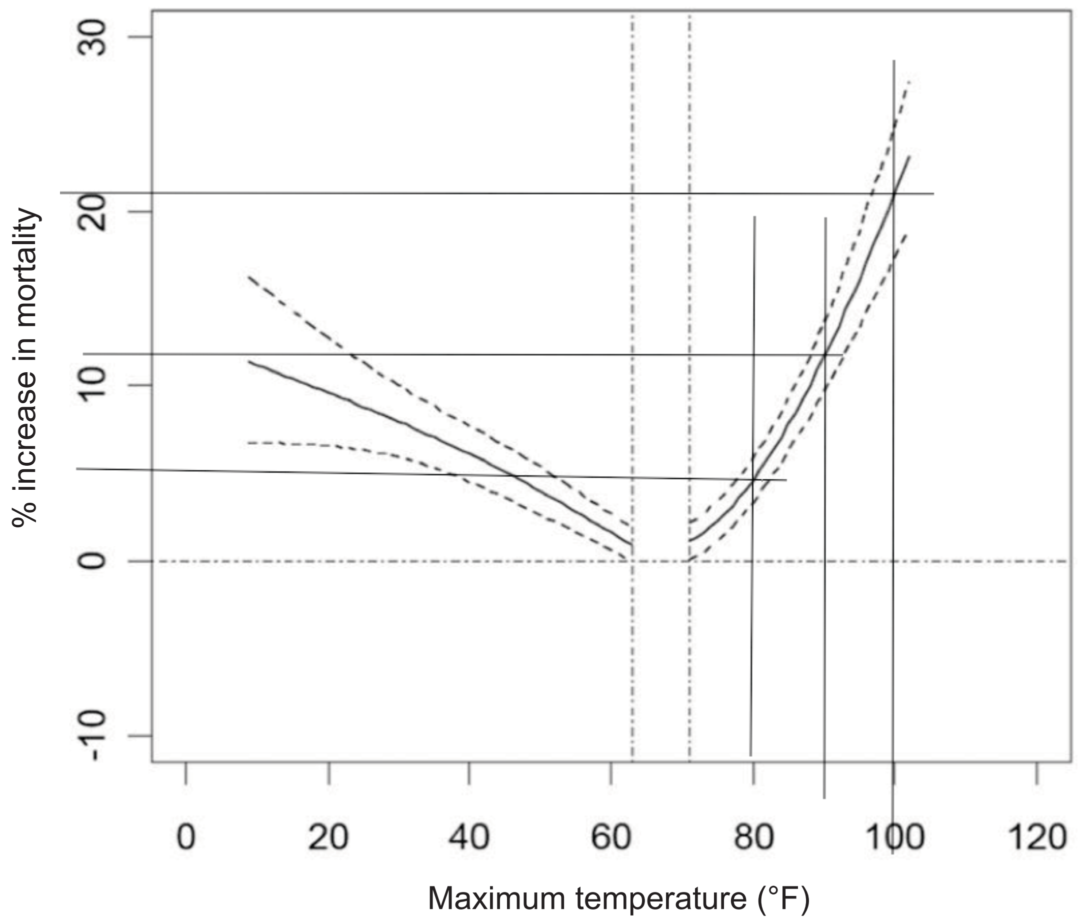


2050 Solar Radiation map

Plant and tree species should be chosen considering soil types, pollution, flood risks and solar exposure. New vegetation should be targeted to local “hot spots”

Value Proposition
Climate-Resilient Urban Design

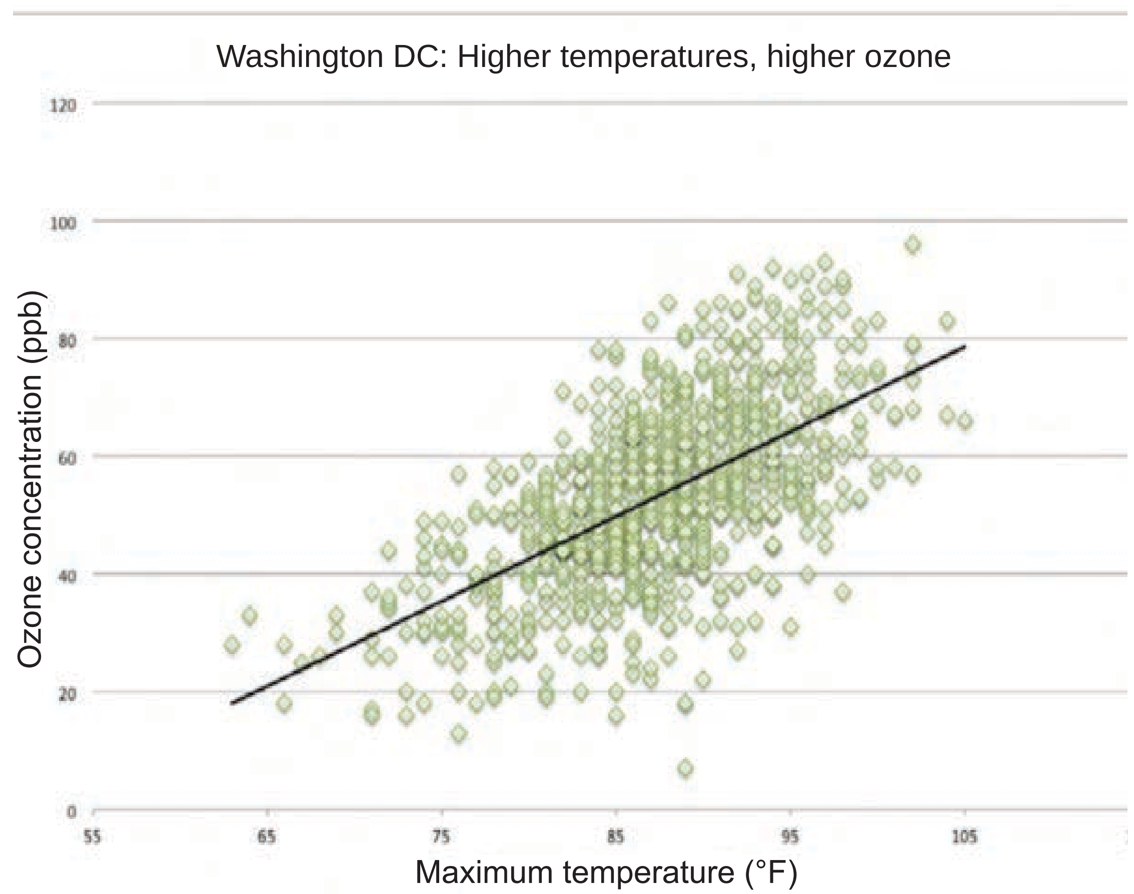
1. Heat-related Deaths



NYC Panel on Climate Change, Chapter 5 "Public Health"

As seen on the figure, each 1°F increase in NYC goes with an increase of mortality. With climate change, 400 additional deaths compared to the 1980s could occur in the 2020s.

2. Air pollution



Ozone concentration and temperature, Summer in the City, Climate Central (2014)

Ozone, a major cause for respiratory diseases, forms from other common pollutants in the presence of sunlight and heat during summer hot days. A strong correlation has been found between daily temperature and ozone concentration.
Even a feasible, modest reduction of 10% in ozone concentrations could prevent more than 80 premature deaths, 180 hospital admissions and 950 emergency department visits per year in NYC.

3. Energy Efficiency

According to EPA (Environmental Protection Agency), research shows that electricity demand for cooling increases by 1.5-2.0% for every 1°F increase in air temperature, starting from 68 to 77°F.

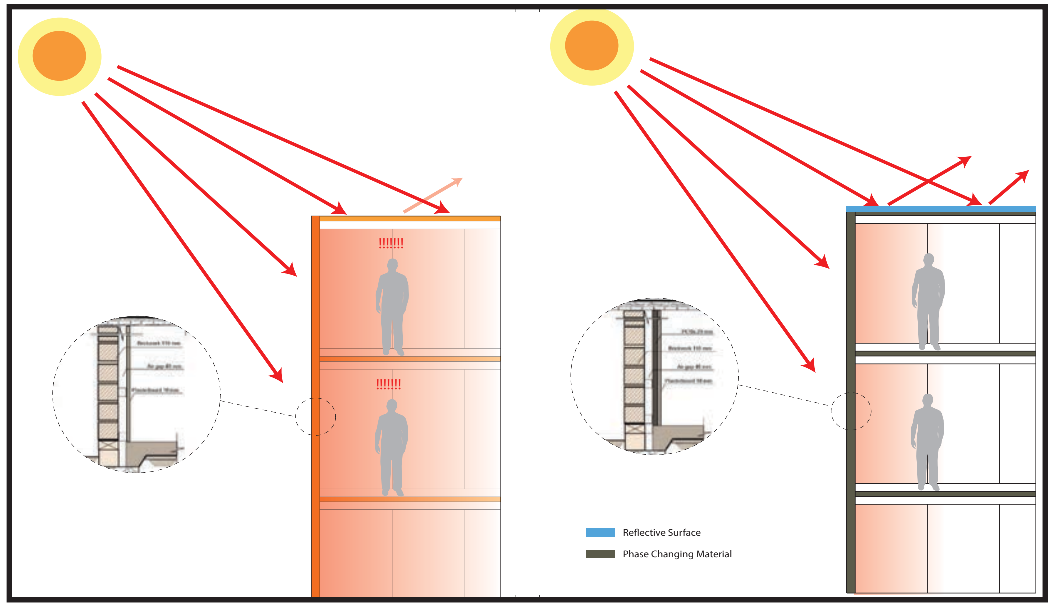
For **every 1°F** of air temperature decrease in the rezoning area made possible by our design guidelines, it is possible to save annually in the rezoning area:

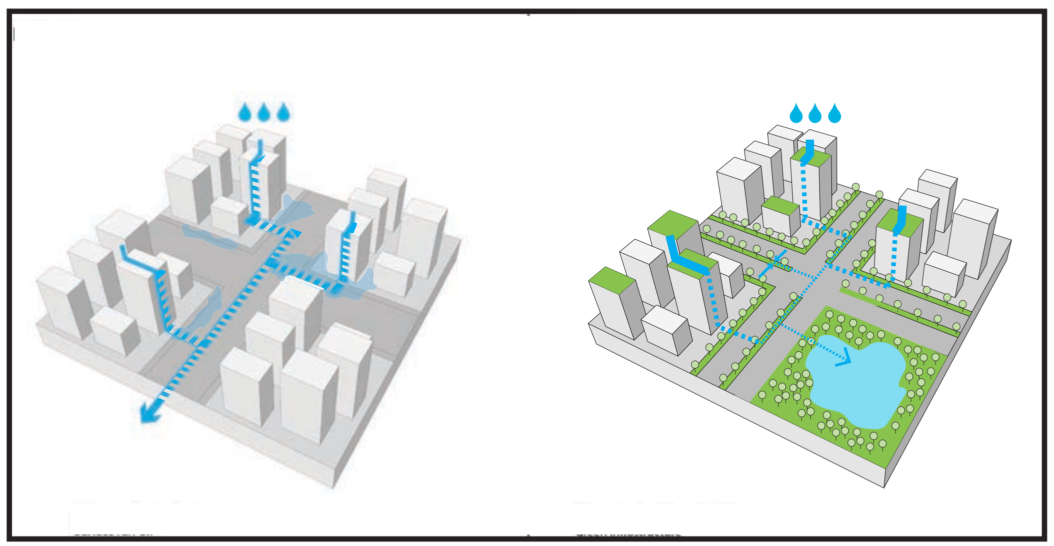
- 1 million $ in electricity

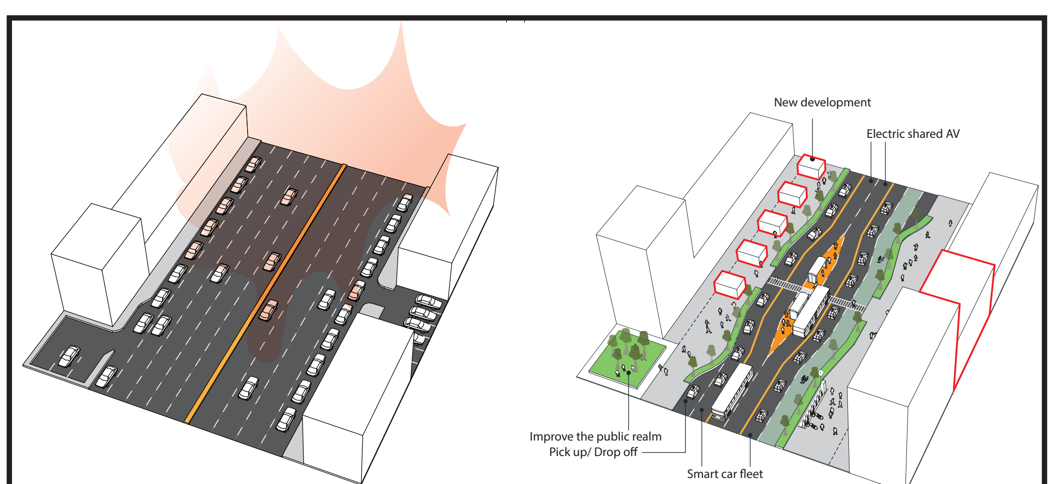
- 1,730 metric tons of CO_2.

Implementation Process

Phasing







Short term:

Cool roofing

Heat-resistant construction materials

Medium term:

Decreased vehicle emission and traffic

Non-motorized bike and pedestrian accessibility

Smart drainage system through green infrastructure

Green roofs and green facades

Include urban heat island evaluation as a requirement in the New York City Environmental Quality Review (CEQR) process.

Implementation Process

Phasing

Long term:

District energy systems

Increased sky view factor through Transfer of Development Rights (TDR)

Wind corridors: linear parks aligned to prevailing summer breezes

Diversity of building forms

Glossary

Urban heat island: An urban heat island is an urban or metropolitan area that is significantly warmer than its surrounding rural areas due to modification of land surfaces and human activities. The annual mean temperature of a city with 1 million people or more can be 1.8-5.4°F warmer than its surroundings in the US (Environmental Protection Agency). The term “urban heat island effect” refers to the phenomenon resulting in this temperature difference.

Urban canyon: An urban canyon, or street canyon, is a relatively narrow street with tall, continuous buildings on both sides, creating a canyon-like environment. Urban canyons affect various local conditions, including temperature, air quality and wind.

Albedo: Surface albedo is defined as the ratio of radiation reflected to the radiation incident on a surface. It is dimensionless and measured on a scale from 0 (corresponding to a black surface that absorbs all incident radiation) to 1 (corresponding to a white surface that reflects all incident radiation).

Transfer of Development Rights (TDR): TDR is a land use regulation that can be used to ensure that the open space requirements of the municipality’s planning goals are met without causing a financial burden to landowners or restricting needed development. It permits all or part of the density potential of one tract of land to be transferred to a noncontiguous parcel.

Privately Owned Public Spaces (POPS): POPS are physical spaces that, although privately owned, are legally required to be open to the public. It was introduced in NYC as a zoning mechanism that offered developers the right to build more floor area in return for plazas.

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