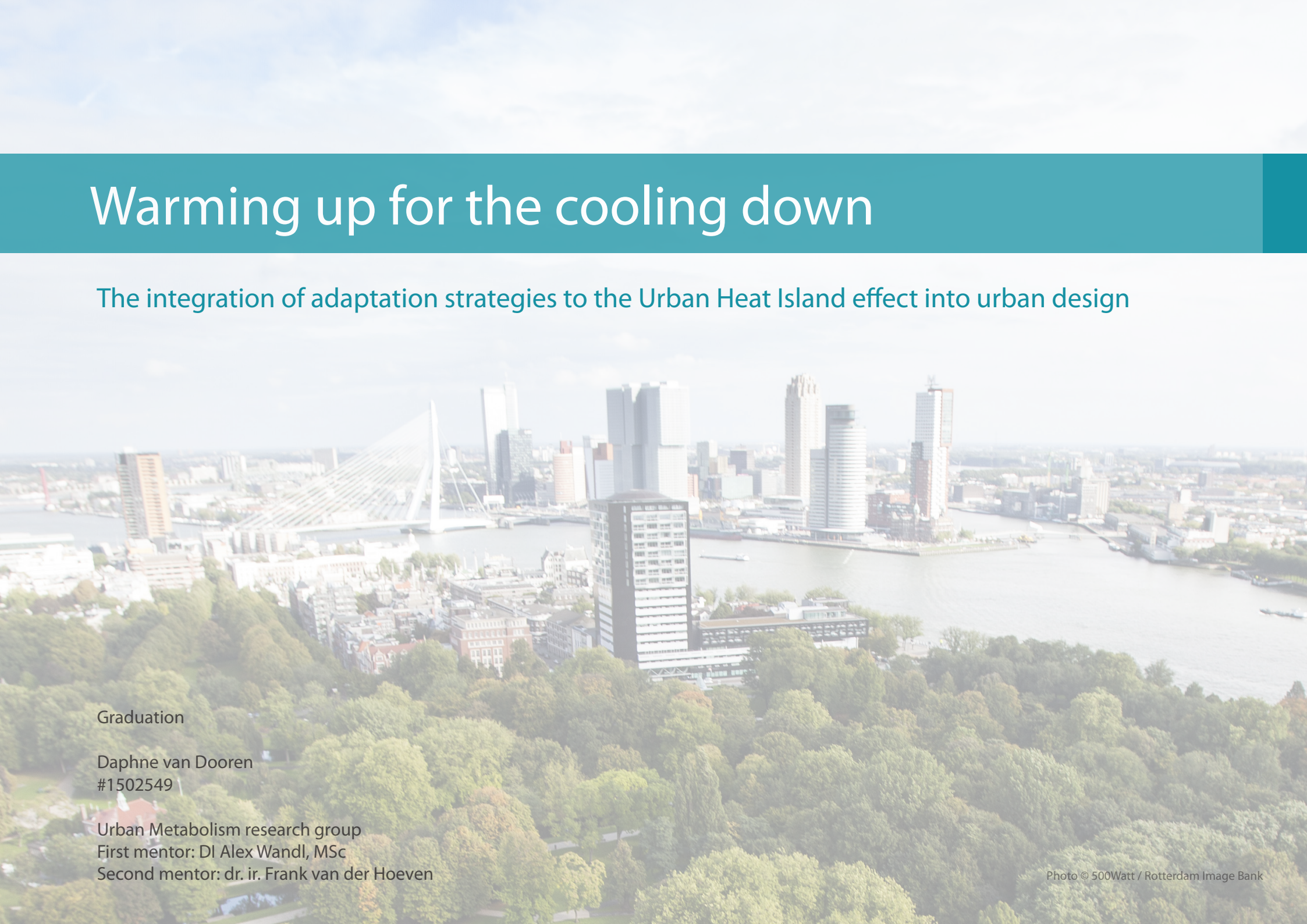
Warming up for the cooling down

The integration of adaptation strategies to the Urban Heat Island effect into urban design



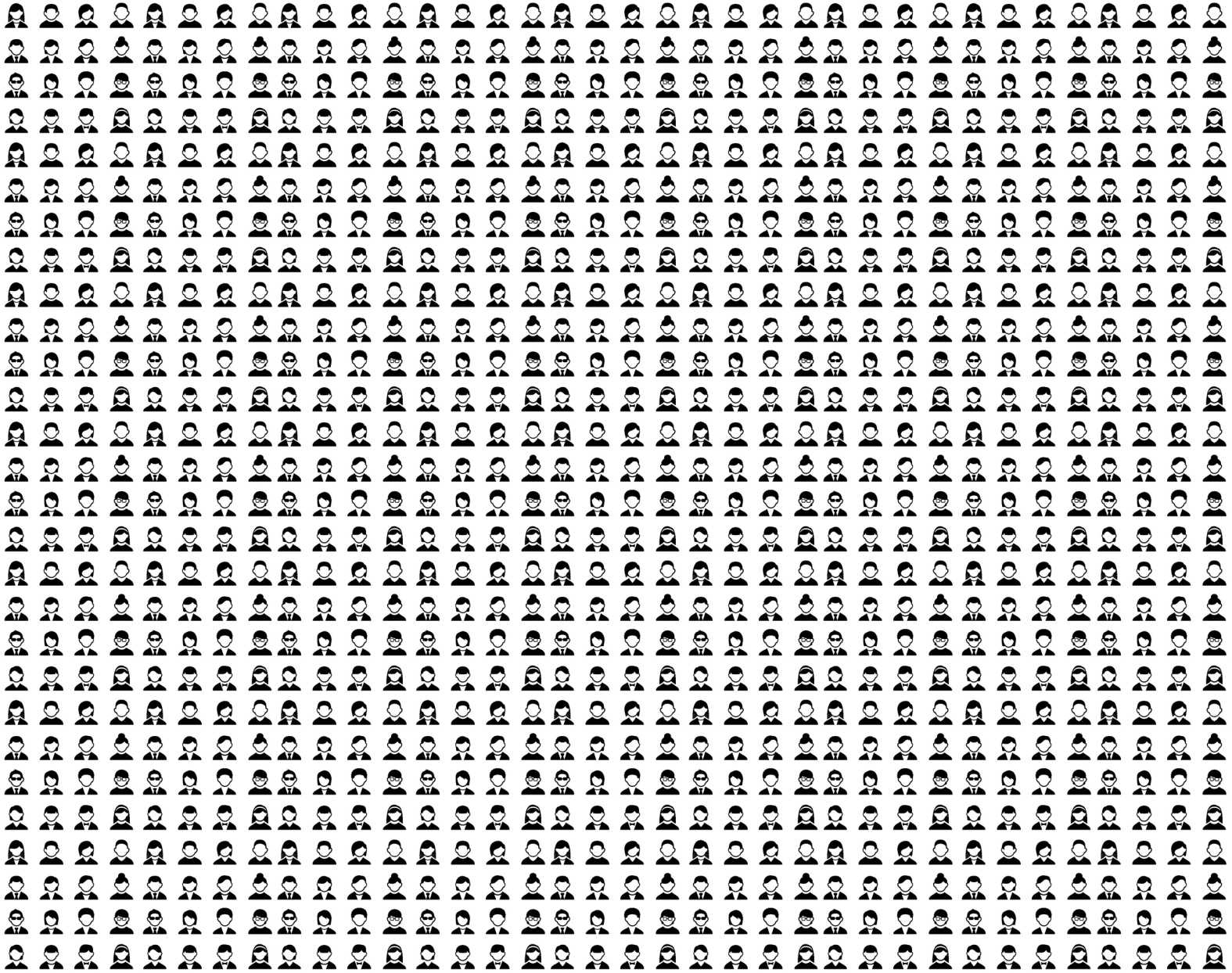
Graduation

Daphne van Dooren
#1502549

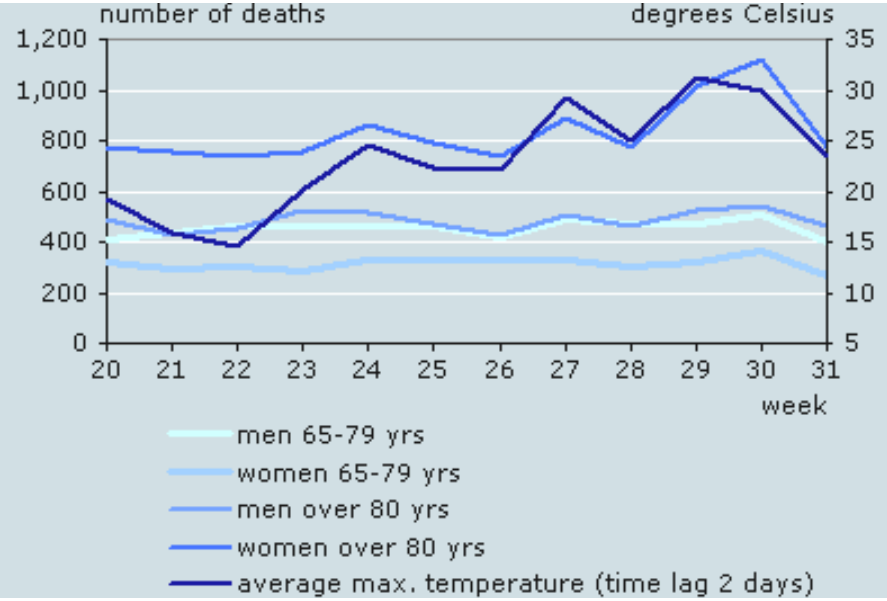
Urban Metabolism research group
First mentor: DI Alex Wandl, MSc
Second mentor: dr. ir. Frank van der Hoeven

Hot summer day

1000 extra deaths

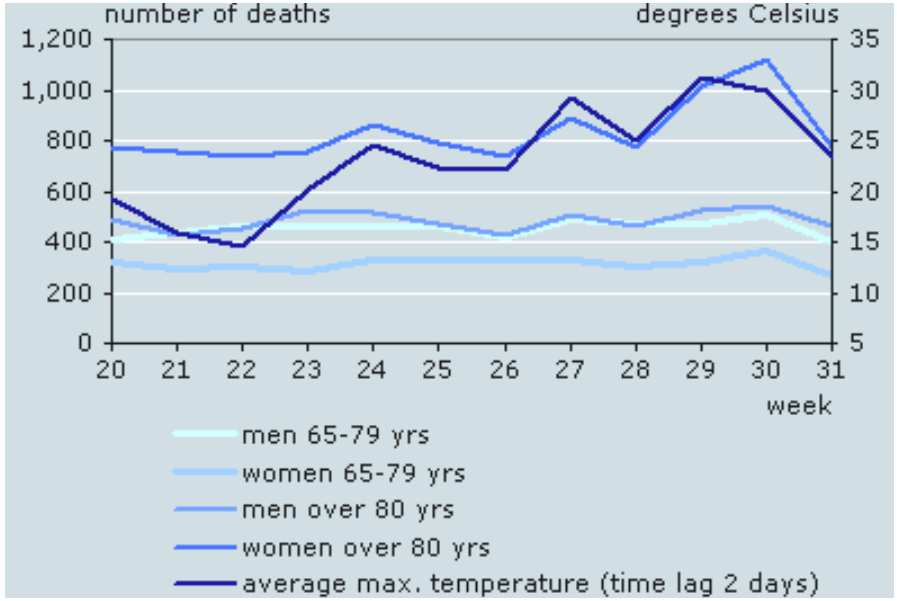


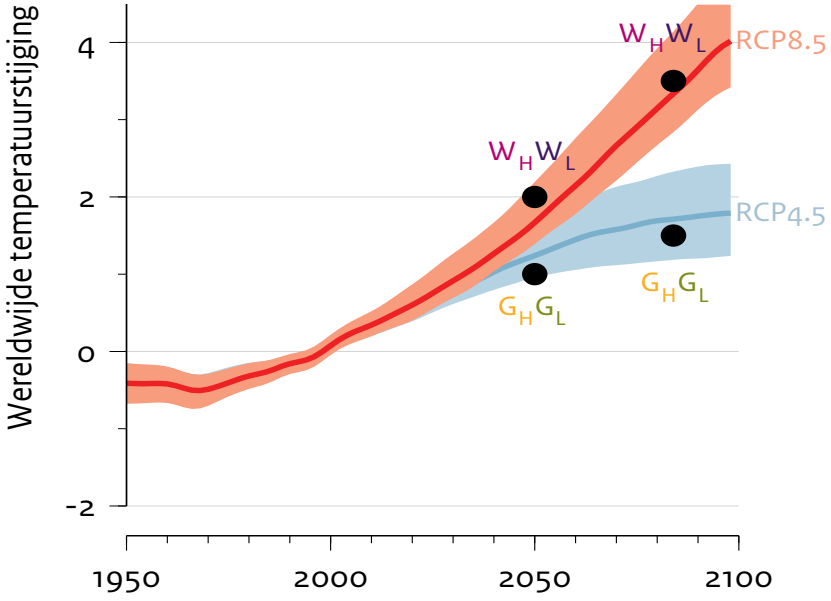
Consequences of heat



Source: CBS

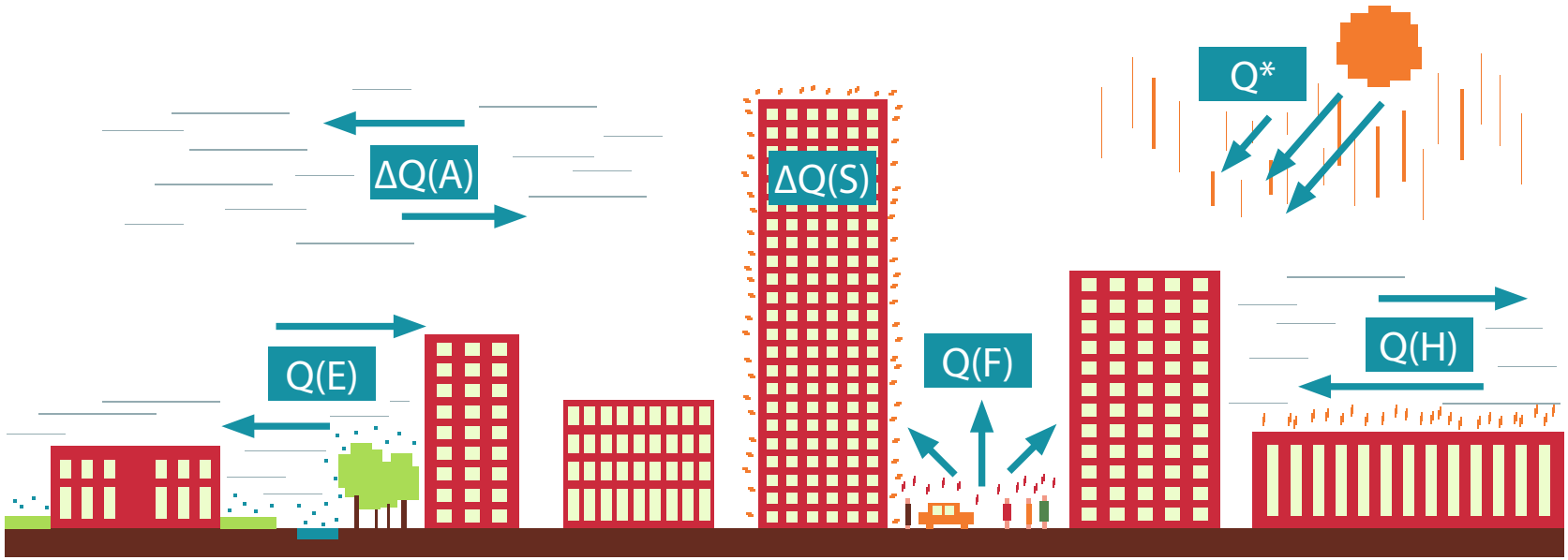
Consequences of heat





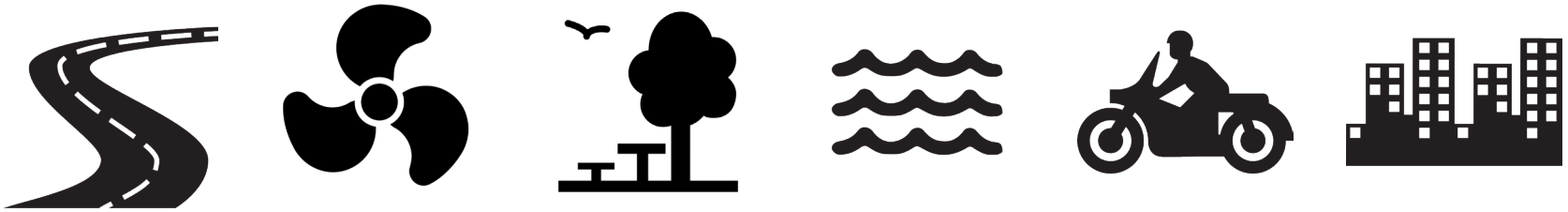
Sources: CBS, KNMI

Urban Heat Island effect



Causes of heat in the city

- Materials with low albedo
- Mechanical cooling systems
- Lack of vegetation/soil
- Lack of water structures
- Anthropogenic heat
- High roughness structure



Source: The Noun Project

Heat related characteristics

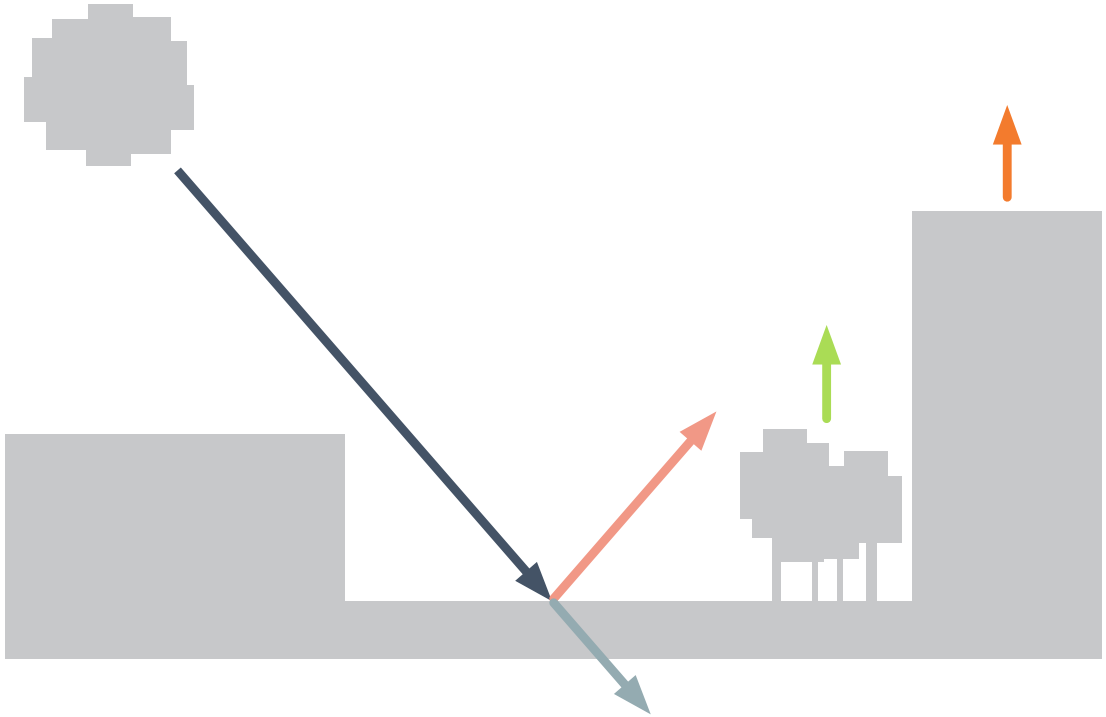
Shadow: reduces radiation

Albedo: reflects radiation

Pervious surface: does not store heat

Sky-view factor: releases heat

Vegetation/water: evapo(transpi)rates



Effectivity of adaptation measure

	weak	moderate	strong
Public / private outdoor space			
Reduces radiation			
Reflects radiation			
Does not store heat			
Releases heat			
Evapo(transpi)rates			
Buildings			
Reduces radiation			
Reflects radiation			
Evapo(transpi)rates			

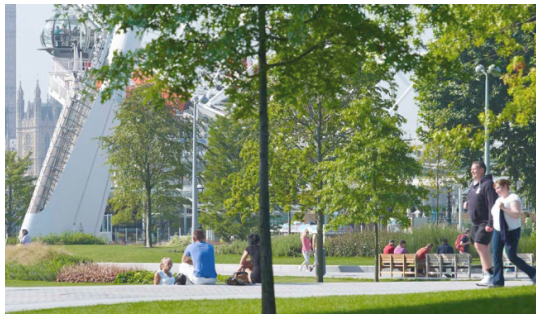
Effectivity of adaptation measure

	weak	moderate	strong	
Public / private outdoor space		*measured for surface of area of intervention*		
Reduces radiation	< 20 %	20 - 50 %	> 50 %	average % covered with shade in Jun-Aug
Reflects radiation	< 0,10	0,10 - 0,30	> 0,30	average albedo
Does not store heat	< 33 %	33 - 66 %	> 66 %	% covered with pervious surfaces
Releases heat	< 0,33	0,33 - 0,66	> 0,66	average sky-view factor
Evapo(transpi)rates	< 20 %	20 - 30 %	> 30 %	% covered (evaporative) vegetation/water
Buildings		*measured for surface of concerning buildings*		
Reduces radiation	< 20 %	20 - 50 %	> 50 %	average % covered with shade in Jun-Aug
Reflects radiation	< 0,10	0,10 - 0,30	> 0,30	average albedo
Evapo(transpi)rates	< 20 %	20 - 30 %	> 30 %	% covered (evaporative) vegetation/water

Adaptation strategies: case comparison

Antwerp
- Scheldekaaien
- Theater square

London
- Olympic park
- Jubilee gardens



Copenhagen
- Ørestaden
- Nordhavnen

Sources: Borret, Perreijn, London Legacy Development Corporation, West 8, CPH City and Port Development

Example: Scheldekaaien, Antwerp

before

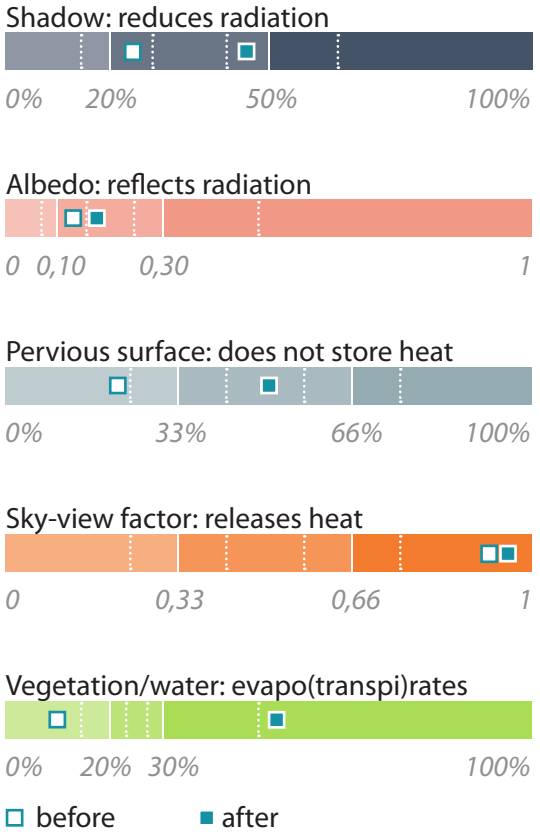
after

Source: Borret

Example: Scheldekaaien, Antwerp

before

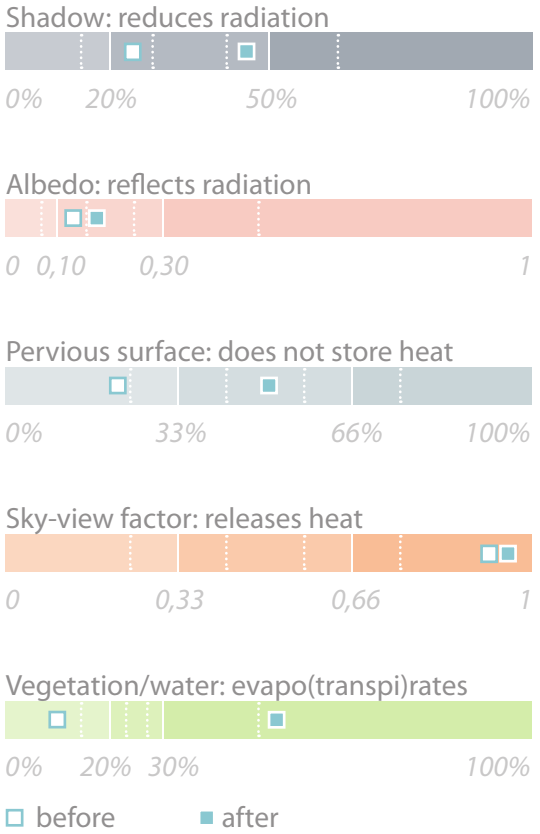
after

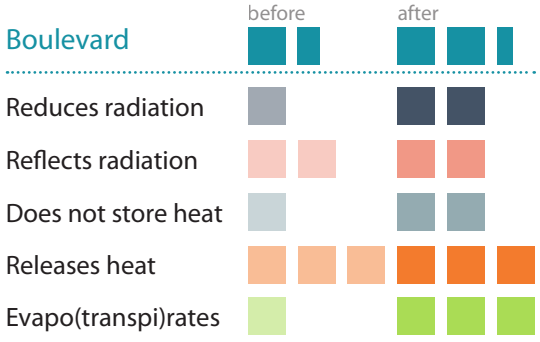


Example: Scheldekaaien, Antwerp

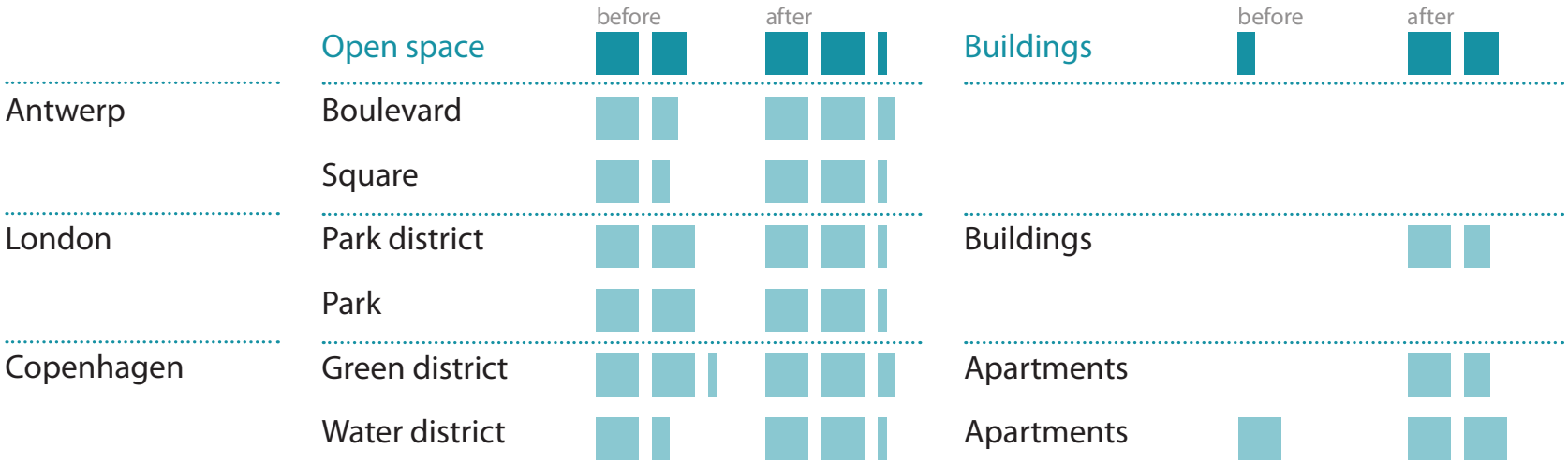
before

after





Conclusions from case comparison



Conclusions:
- All adaptation strategies have led to improved situations.
- Both large scale and small scale projects are effective.

Pattern language

9. Water stream

A water stream is very shallow and moves, which does not allow heat to be stored, and helps to release heat both passively and actively.

Does not store heat
Releases heat
Evaporates

Context
Water streams can be constructed in a formal or informal way. When it is done in an informal way, it often looks like a natural water stream. Formal designs are more often used in an urban context. Moving water is attractive for children to play with, and because the water stream is very shallow, it is safe to do this. Also, it is possible to make crossings over the water stream, with the result that it is not a barrier. Sometimes the stream is small enough to reach the other side by taking one step only. Besides the dynamic effect of the streaming water, it also creates a calm sound.

Solution
By creating a water stream, the temperature can be lowered in different ways. Besides the fact that the streaming water does not store heat, it also releases heat in a passive and active way. The air above the water cools down, because the heat goes up to the open sky above it. Also, the water evaporates, which leads to lower temperatures. An extra effect the water stream can have, is that people can touch the water to cool themselves as well.

Physical restrictions
- The water body should not be a barrier for the surrounding area.
- It should be possible to construct a height difference and a water pump system.

Heat characteristics
- does not store heat:
the small layer of streaming water does not store much heat
- releases heat:
heat is released to the air above the water
- evaporation:
by means of evaporation, the water can cool the air

Application scale
- street scale
- neighbourhood scale

Typologies of space
- shopping center
- square
- park
- green zone

Combination with other patterns
- fountain
- high albedo pavement

Bospolder-Tussendijken
For a water stream it is an advantage when there is a natural height difference. This can be found in the area along the Dakpark. Some other larger areas have a slight difference in height, but then an extra height difference should be added. The water stream is mainly helpful against heat in terms of perviousness and evaporation.

Cool
In the Lijnbaan area some height differences can be found. Therefore, it is possible to create a very small waterstream in the shopping streets. The inner courtyards are also suitable to construct a waterstream. In the southern part of the area, there is a height difference as well.

Pattern language

hypothesis/summary

context application

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description/
explanation

possible application
in neighbourhoods
Rotterdam

Example pattern

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Patterns

urban agriculture

roof garden

water body

solar panels

high albedo pavement

pergola

green balcony

green facade

trees

wadi

canopy

smart parcellation

sunshade

permeable pavement

vegetation

grass

water stream

high albedo roof

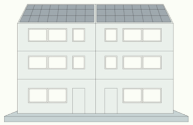
Pattern model

building scale

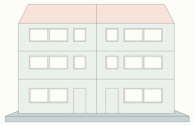
city scale

15. Green balcony

18. Solar panels



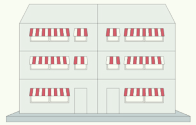
17. High albedo roof



14. Green facade

16. Roof garden

13. Sunshade



1. Canopy

2. Pergola

7. Wadi

10. Fountain

12. Permeable pavement

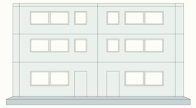
6. Grass

4. Vegetation

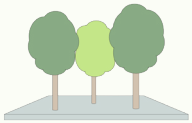
5. Urban agriculture

9. Water stream

19. Smart parcellation



3. Trees



8. Water body

11. High albedo pavement

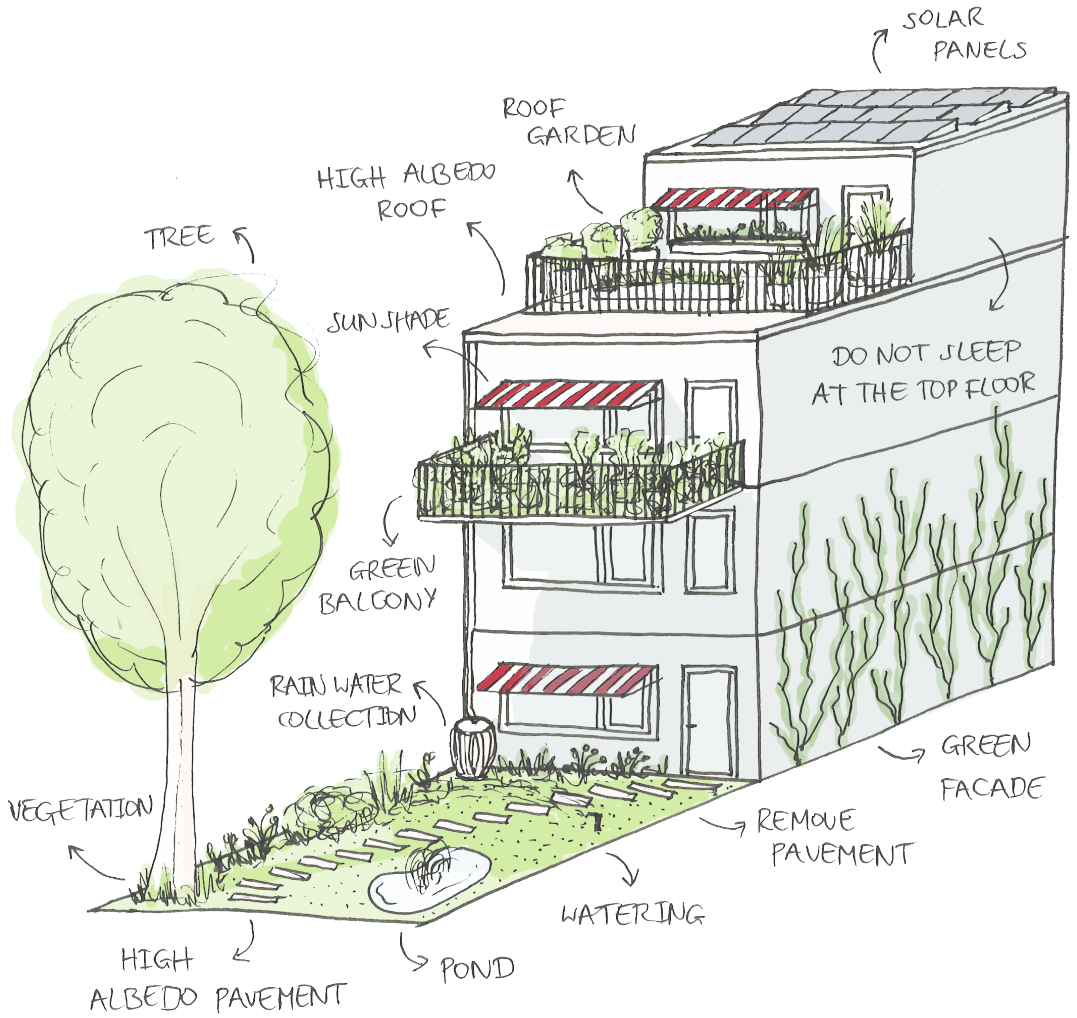
What inhabitants can do

1. Keep windows closed.

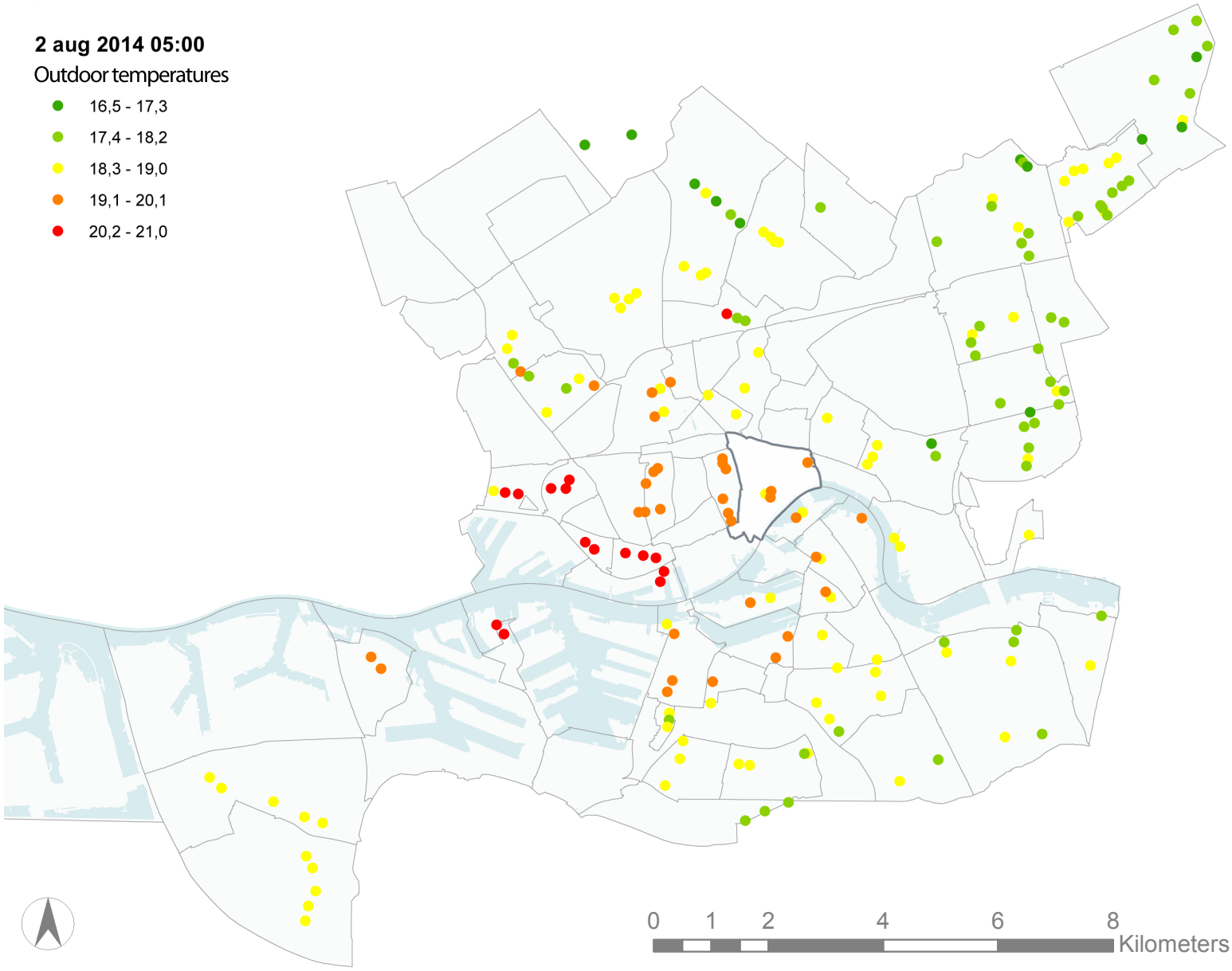
2. Keep the sun out of the house.

3. Make the house heat proof.

4. Make the garden heat proof.

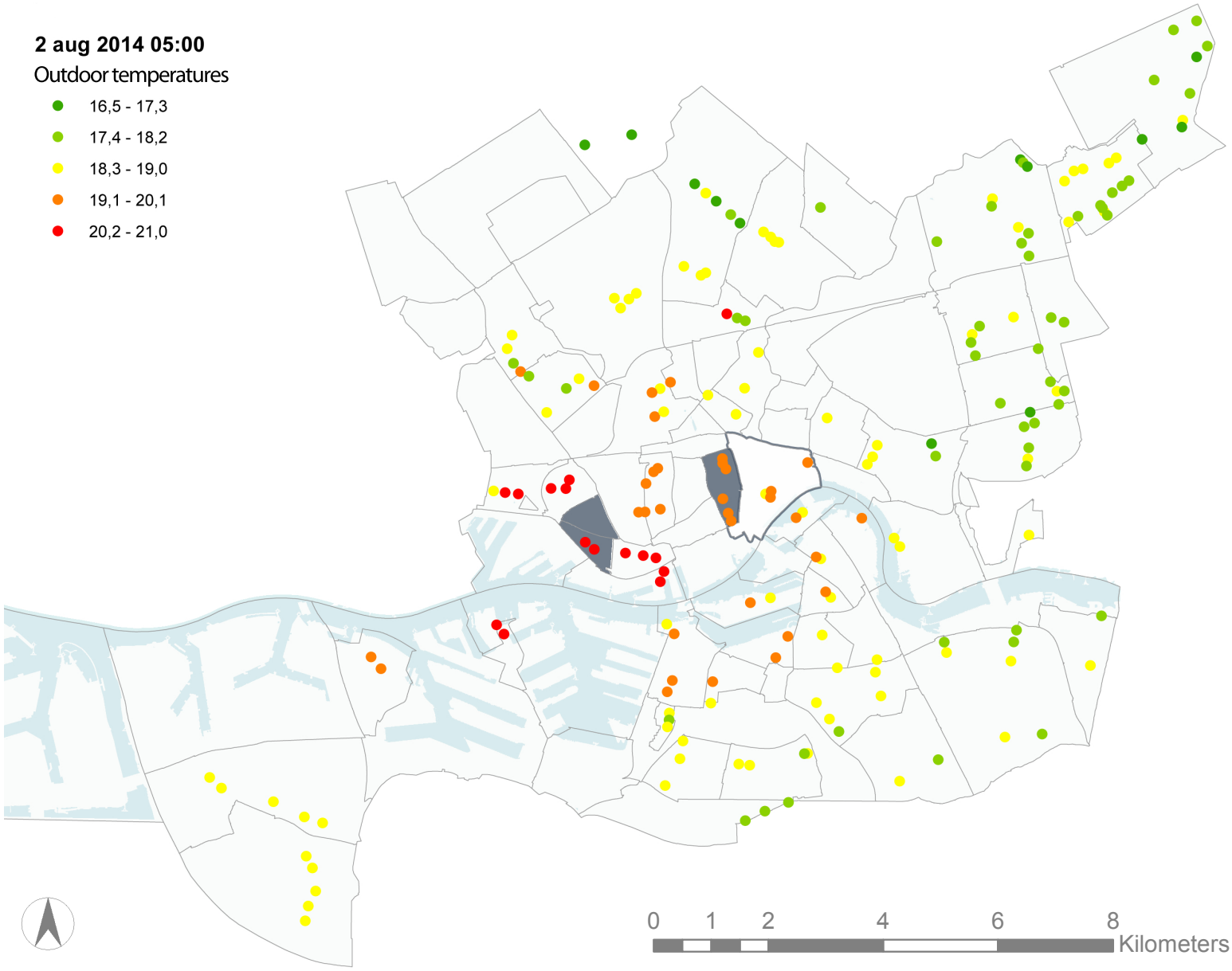


What Rotterdam can do

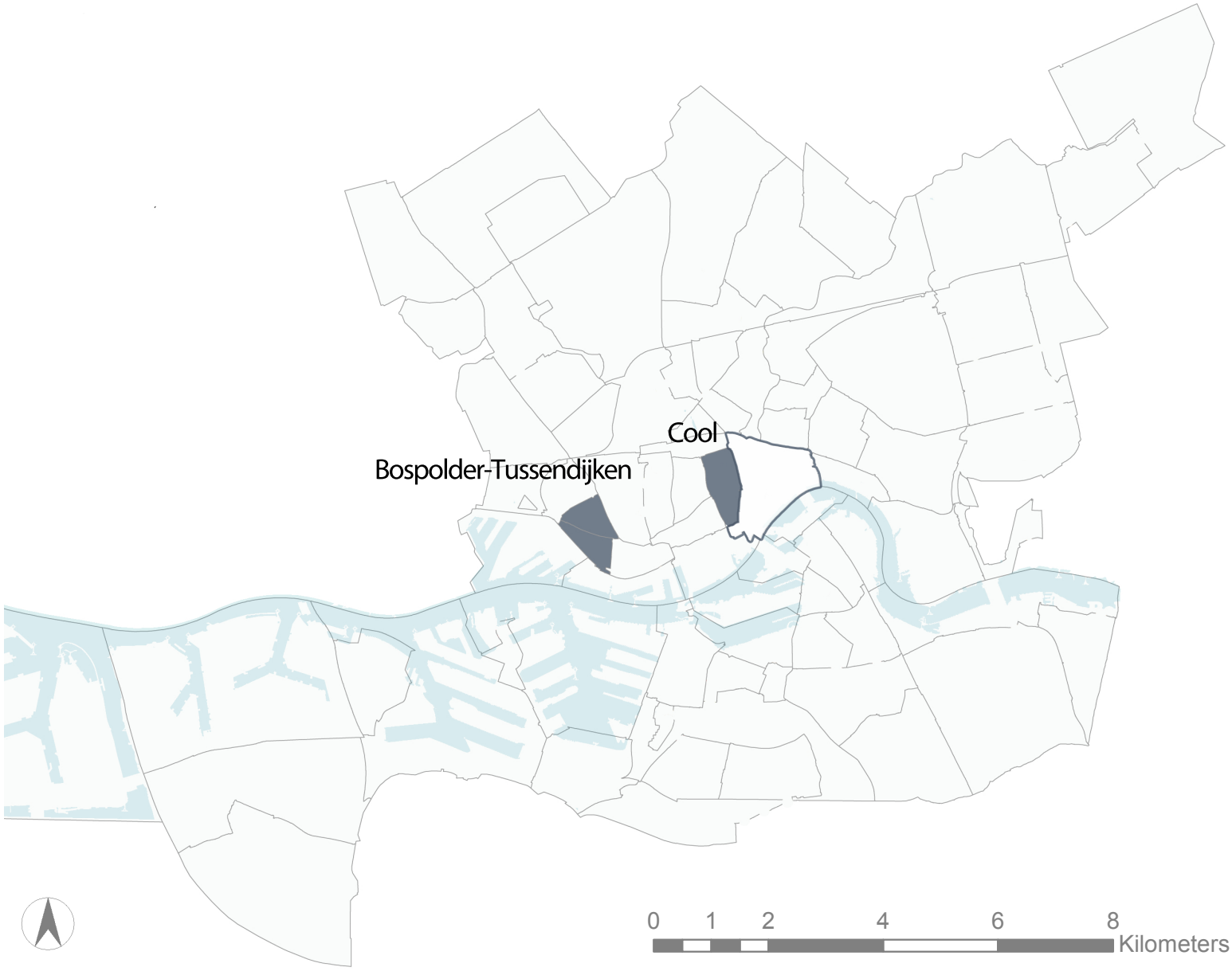


Source: Hotterdam

What Rotterdam can do



Two neighbourhoods as test case



Areas of development

Design example: Visserijplein

Current situation

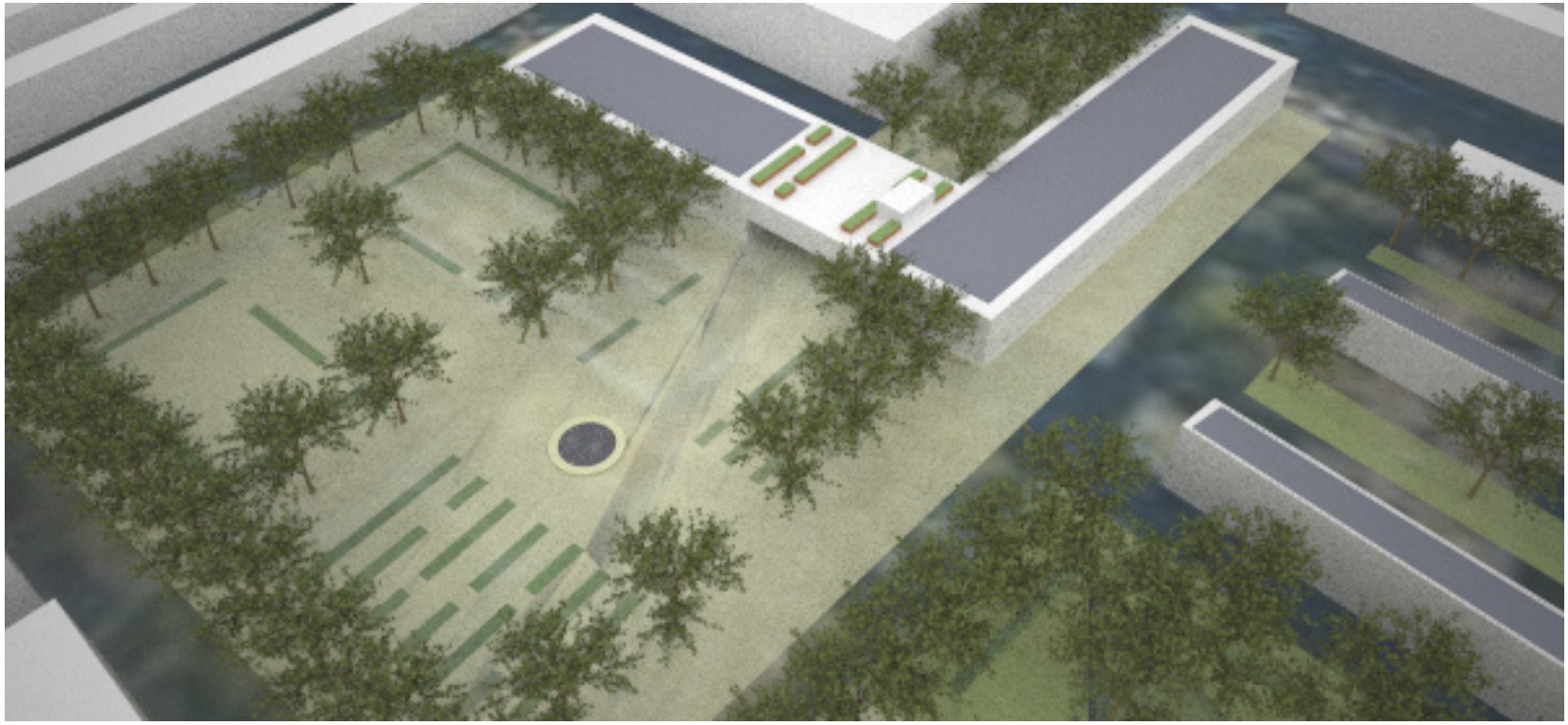
- Only used twice a week for the market
- Empty space, out of proportion

Goals

- Multifunctional use of the community building
- Market as determinative element for neighbourhood

Design example: Visserijplein

Variant 1: Focus on policies



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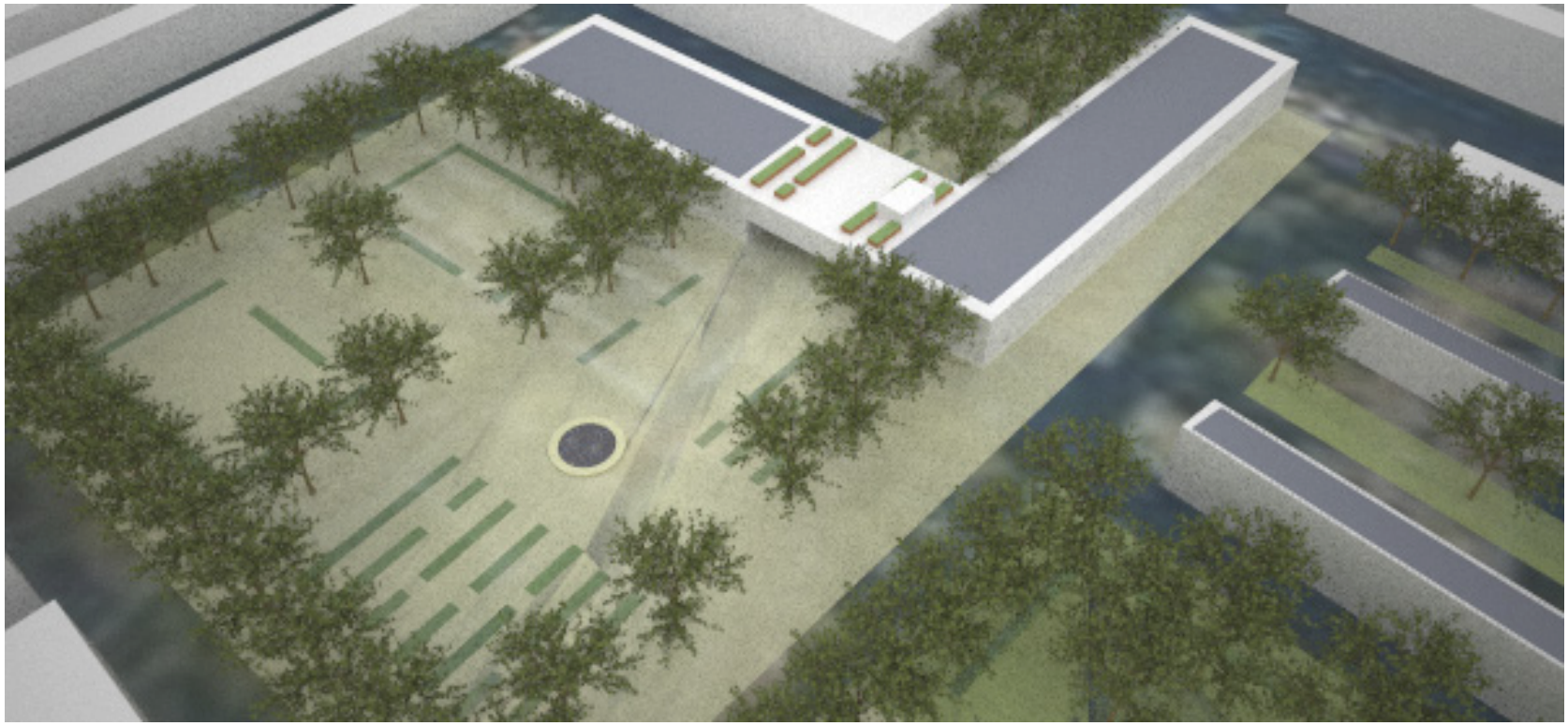

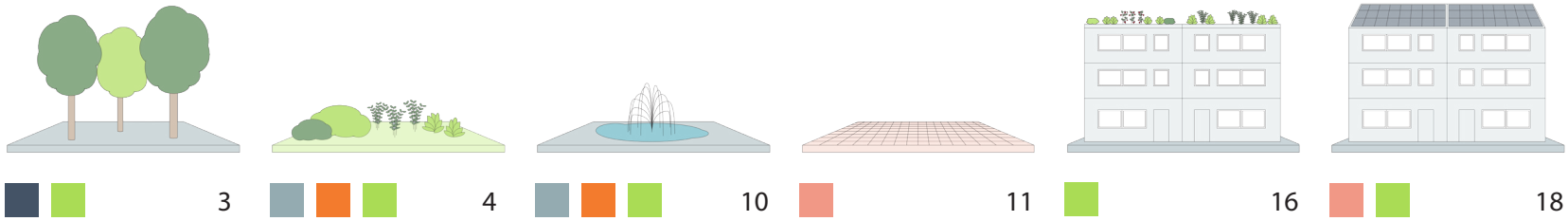

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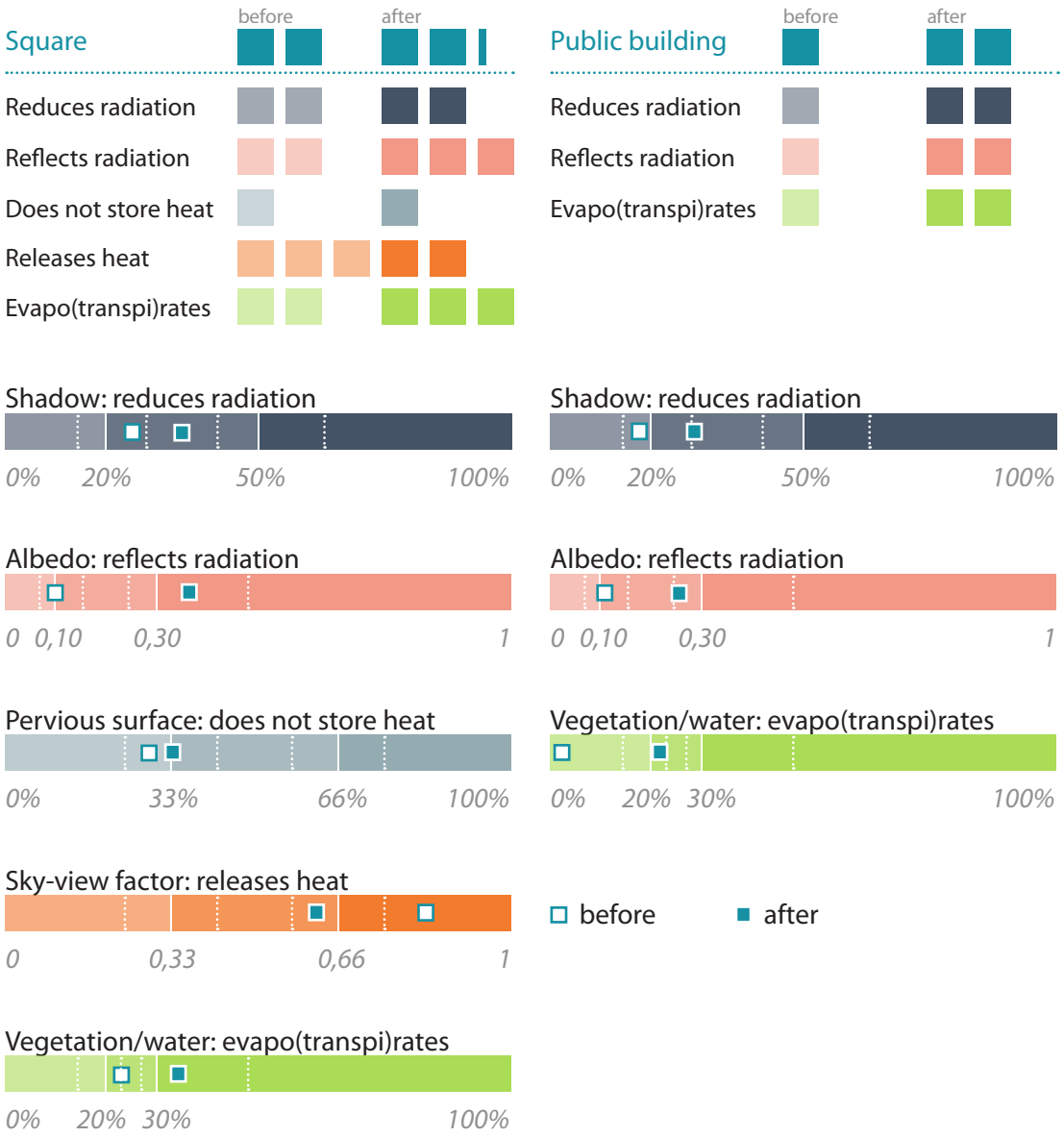
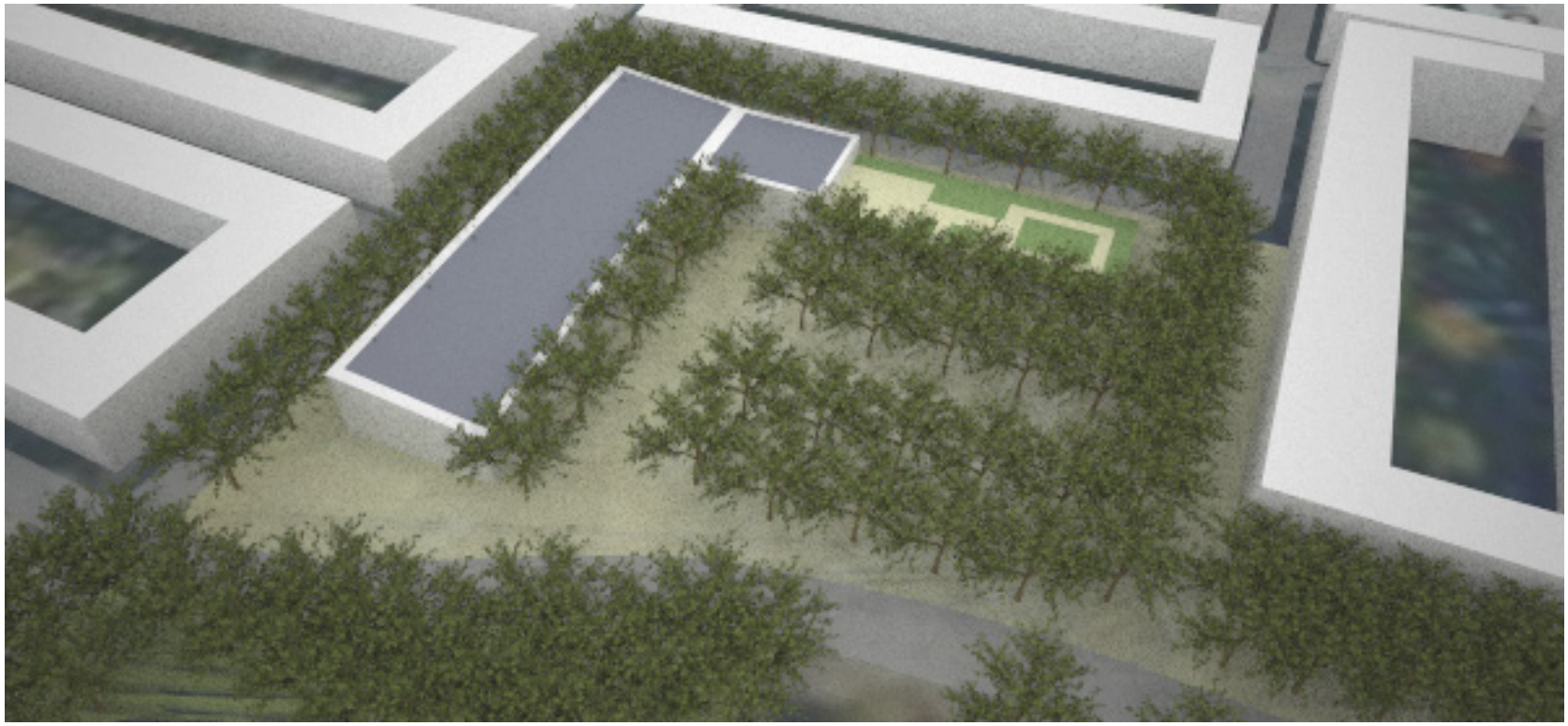


Design example: Visserijplein

Variant 2: Focus on improving the heat characteristics



Design example: Visserijplein

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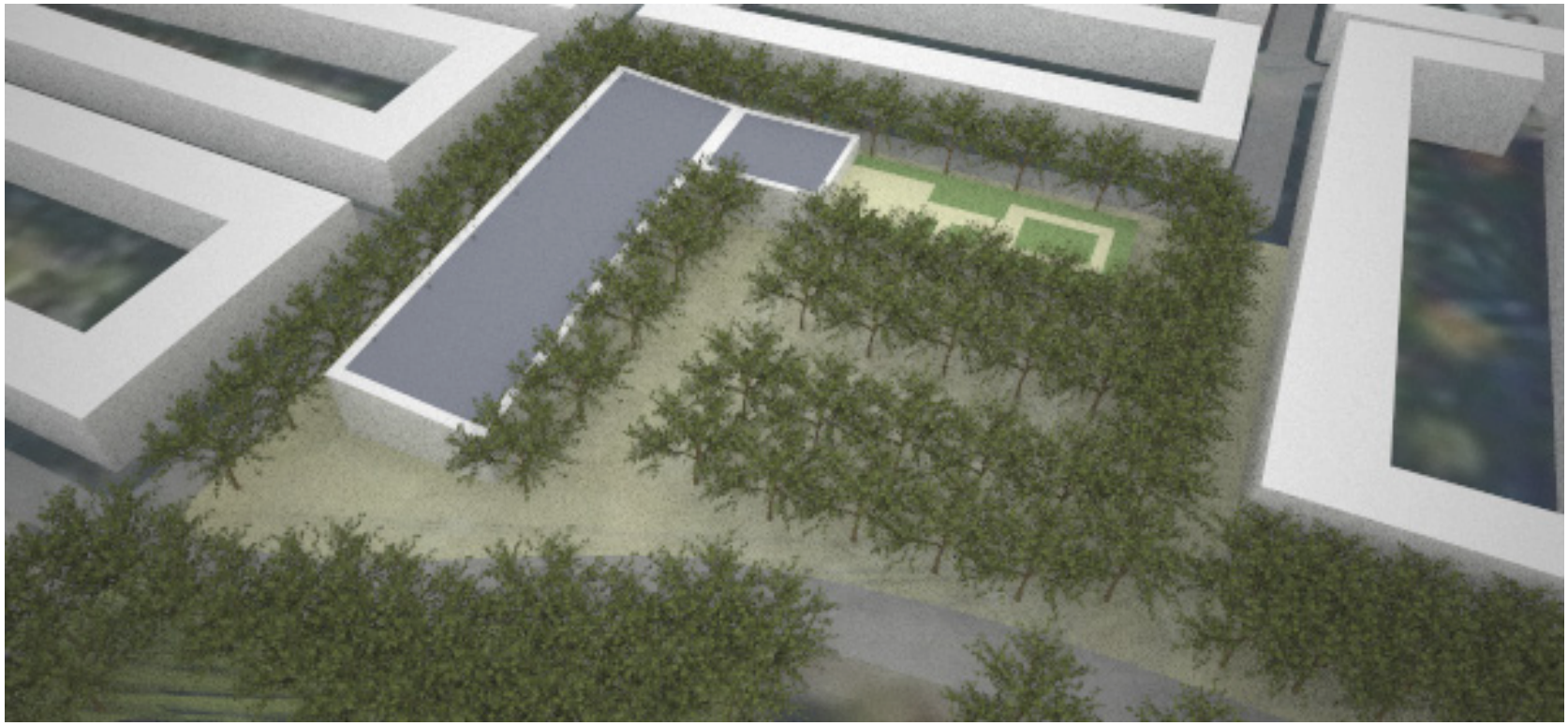
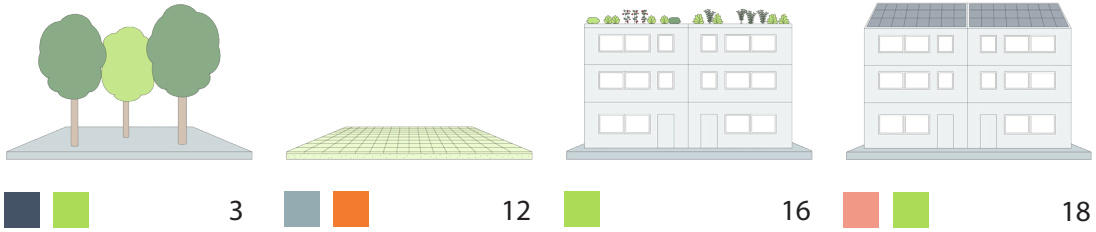
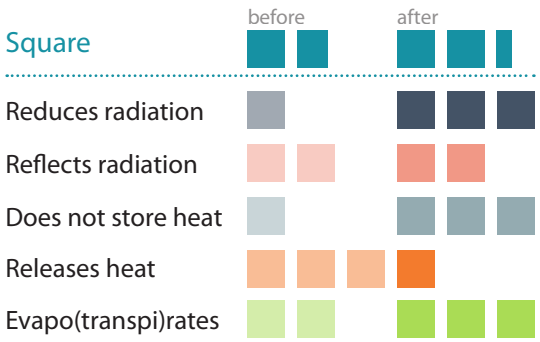
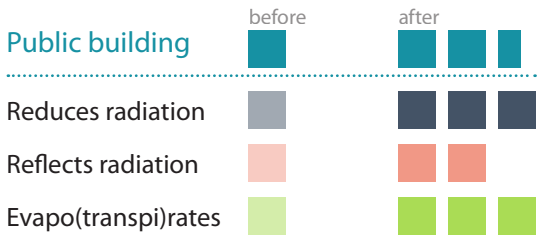
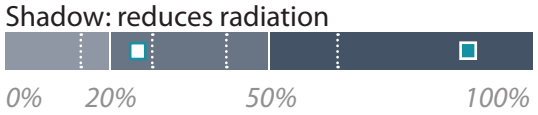


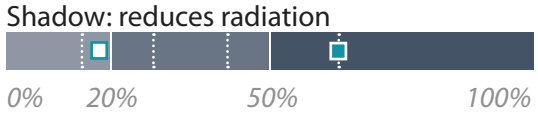


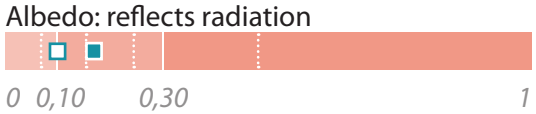
Design example: Visserijplein

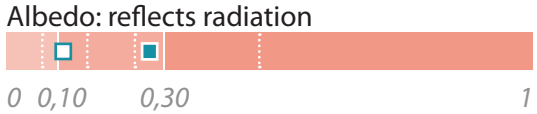


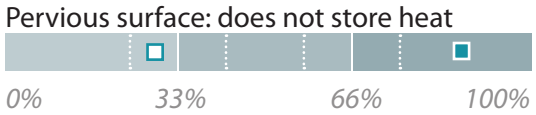


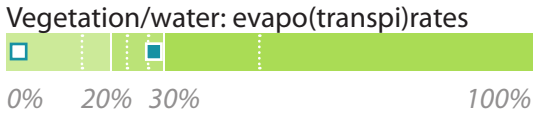


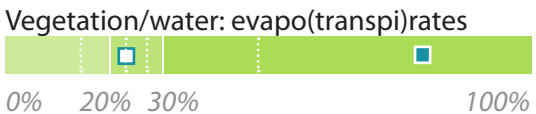








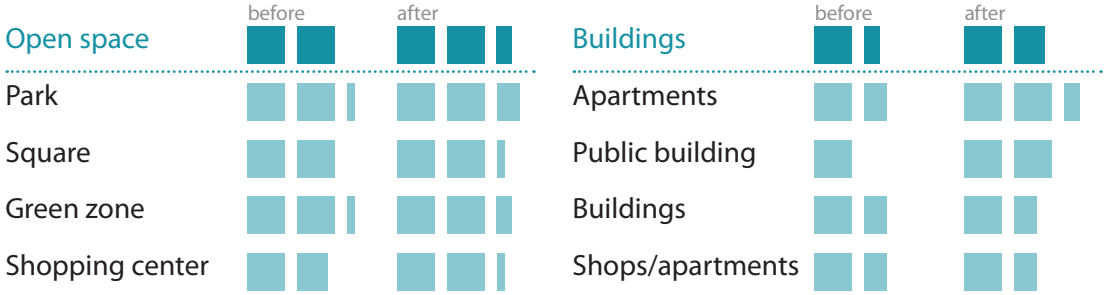




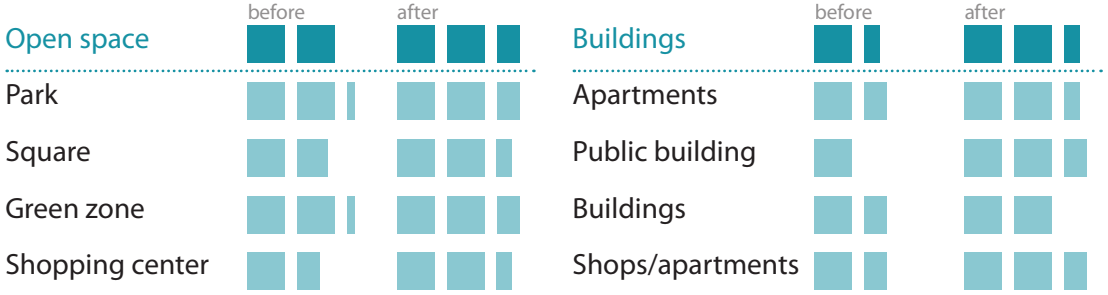
Urban designs

Conclusions urban designs

Variant 1: focus on policies

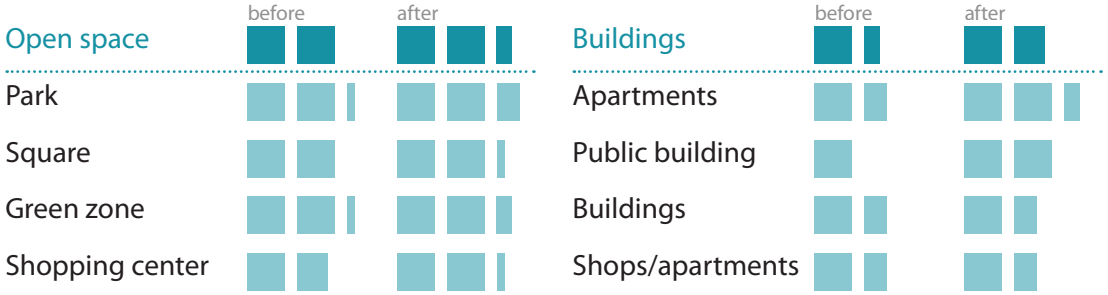


Variant 2: focus on heat related characteristics

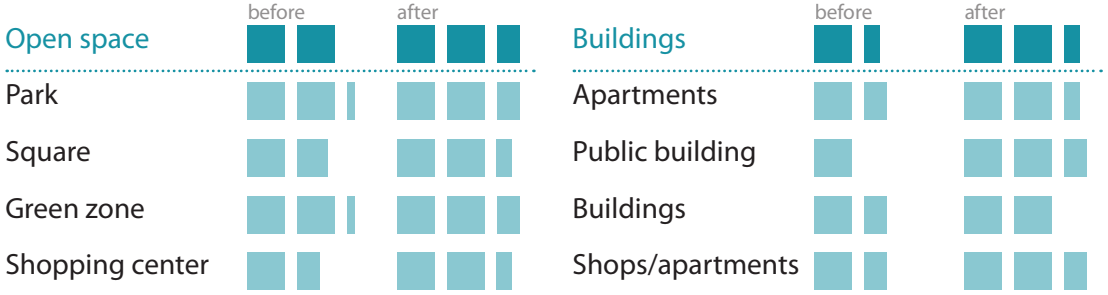


Conclusions urban designs

Variant 1: focus on policies



Variant 2: focus on heat related characteristics



Conclusions:

- All urban designs have led to improved situations in terms of heat characteristics.
- There is a slight difference in effectivity between the variants for open spaces.
- Variant 2 is especially more effective for buildings.

Thank you!

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