The effectiveness of heat stress interventions

How to adapt urban areas to heat stress?

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RESILIO BLAUW-GROENE DAKEN

COOLTOWNS

Amsterdam University of Applied Sciences

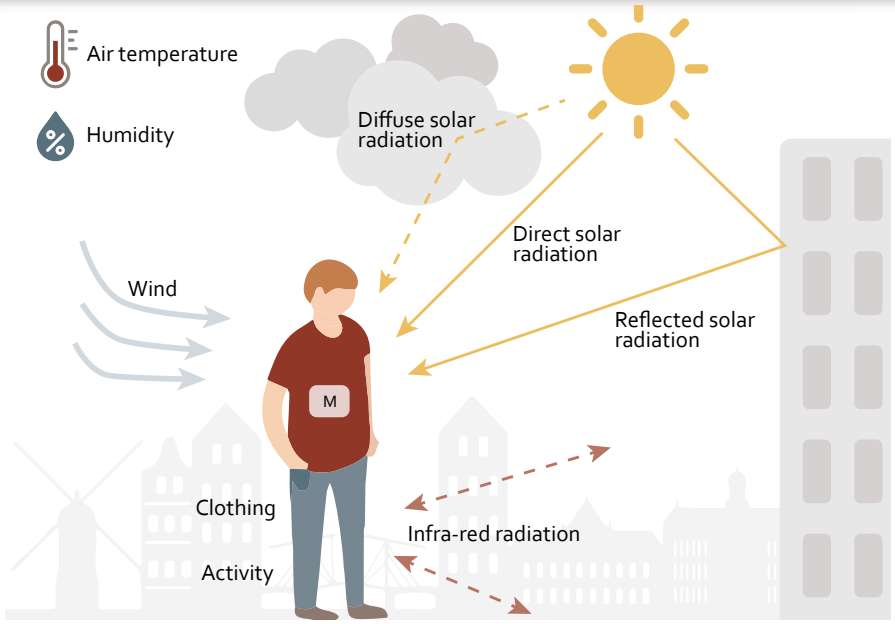
UIA URBAN INNOVATIVE ACTIONS

Interreg 2 Seas Mers Zeeën

UNIVERSITY of GREENWICH

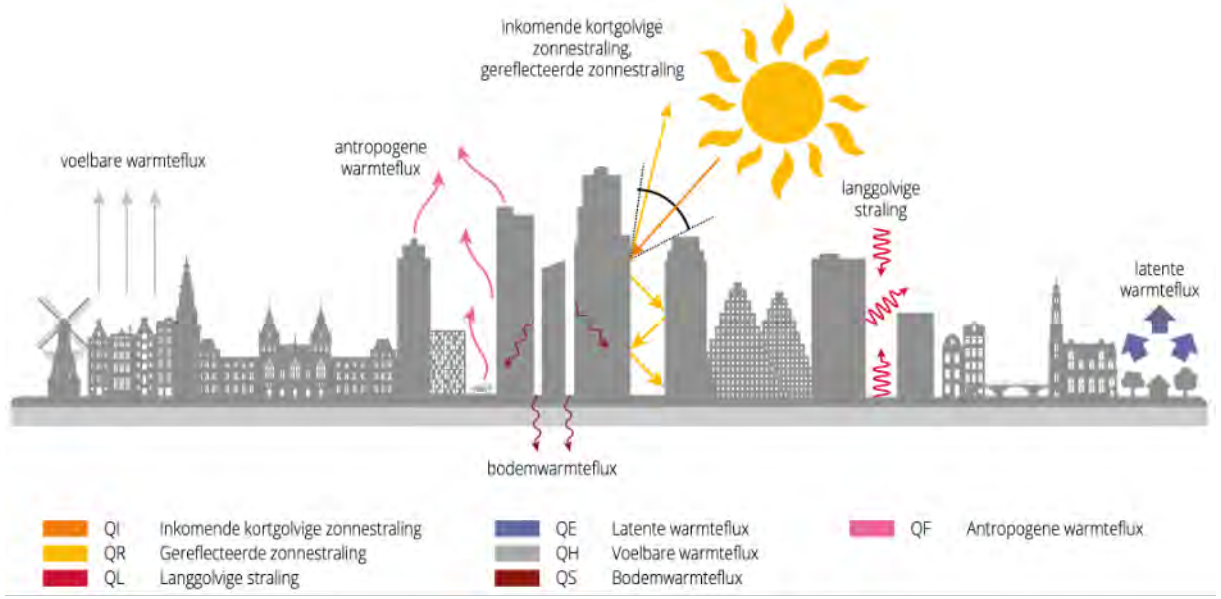
Heat adaptation measures target two goals

Mitigate the perceived temperature locally (PET or gevoelstemperatuur)



The heat balance of the human body (Adapted from Havenith (1999))

Cool the air temperature on a city scale (UHI)



The heat balance of the city (Research Hittebestendige Stad)

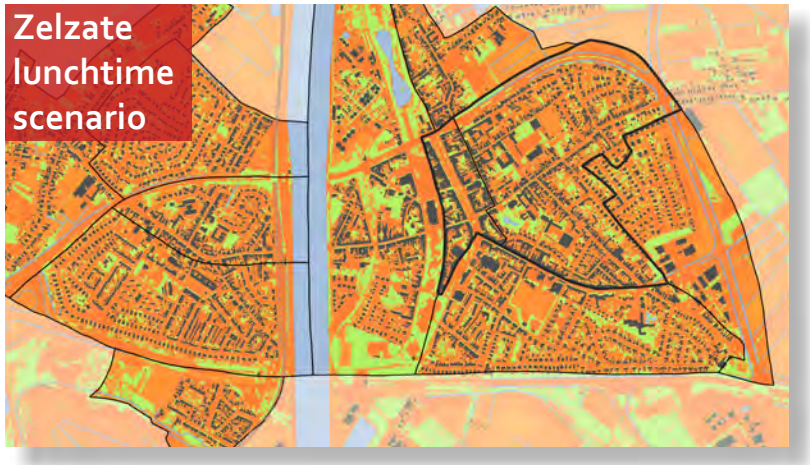
If, a person experiences a PET of 50°C outdoors, based on a combination of different meteorological parameters, the equivalent indoors would be an air temperature of 50°C, without the wind and solar radiation, but at the same humidity.

Thermal City Life (TCL) scenarios

When is it justified to create interventions?

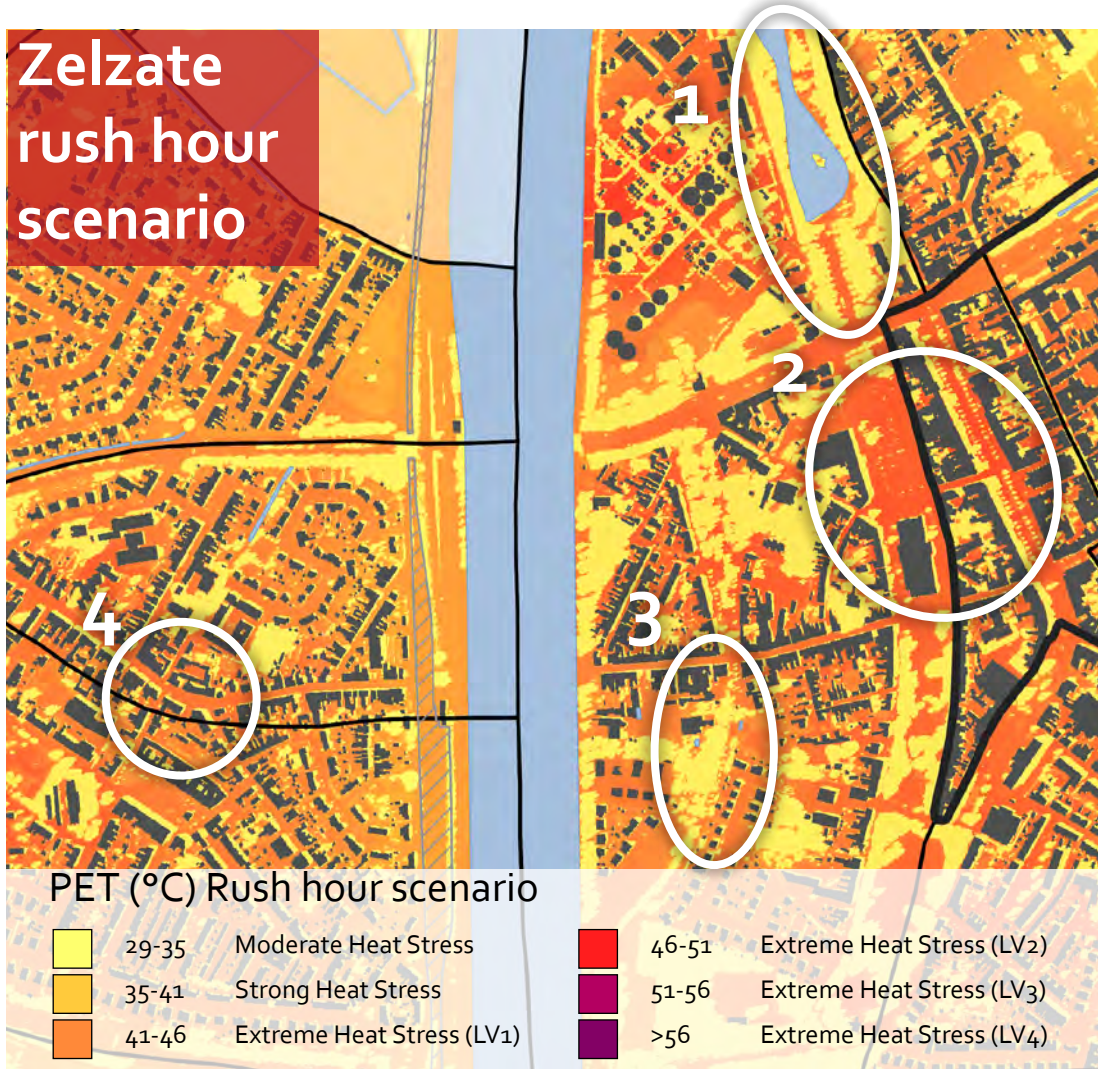
- Connected to social use of the city
- To capture hourly heat dynamics

- Based on a period of persistent heat, 30 years of meteorological data-sets analysed



TCL scenario	Hour	Social activities	Air temperature	Wind direction	Wind strength	Solar radiation	Humidity
Lunchtime	12:00 UTC (14 CEST)	e.g. children play outdoors, lunch break, shopping in centre	28	0 ° (almost no wind)	1.0 m/s	750 W/m2	49 %
Rush hour	15:00 UTC (17 CEST)	e.g. commute home, children play after school, heat builds up	33	90 ° (east wind)	4.0 m/s	600 W/m2	29 %

Where do we see areas with heat stress?



1: City parks can offer a cool escape

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2: Transport hubs are often vulnerable locations

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3: Trees in a row or pocket parks can create cool routes

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4: Primary residential route needs shade

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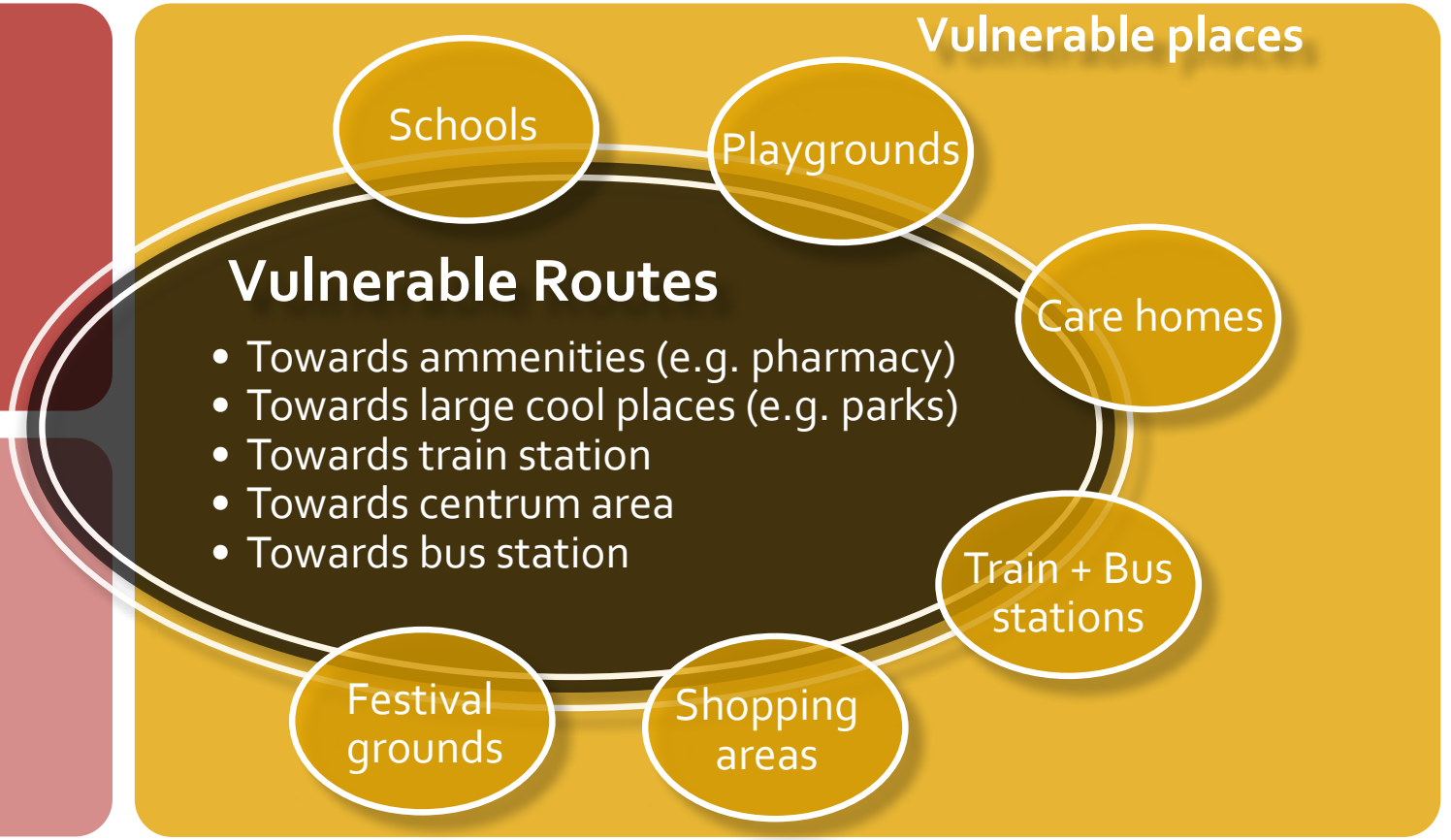
Vulnerable places, health and activity groups

Vulnerable health groups

- Elderly
- Children
- Ill people
- Living alone (social isolation)
- Low socio-economic status

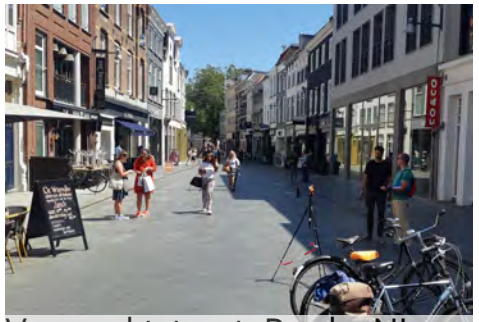
Vulnerable activity groups

- Commuters (on foot & bike)
- Leisure (escape the heat)
- Sport players
- Shoppers (daily)



Vulnerable spatial typologies

City centres / Shopping areas



Veemarktstraat, Breda, NL

Schools / Playgrounds

de Reigers School, Zelzate, BE

Residential neighbourhoods

Waverley Road, Margate, UK

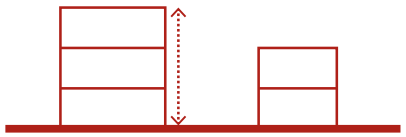
Mobility hubs

Bus station, Middelburg, NL

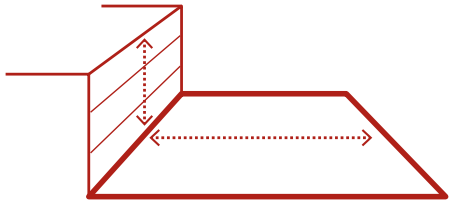
Pedestrian / Cycling routes

Coehoornstraat, Breda, NL

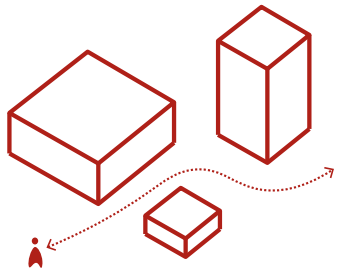
- Identifing vulnerabilities in and between outdoor spaces
- Resolving through tactical small-scale interventions as a start



Urban Geometry

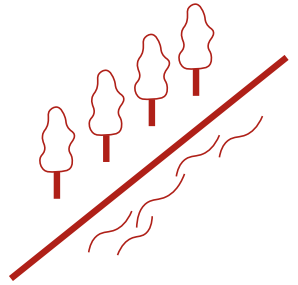


Height-Width Ratio



Social Movement

User-groups



Green-blue infrastructure

How do we measure thermal comfort?

PET measurement:

Mobile weather station measures multiple variables

Air temperature measurement:

Using a hand-held meterological station

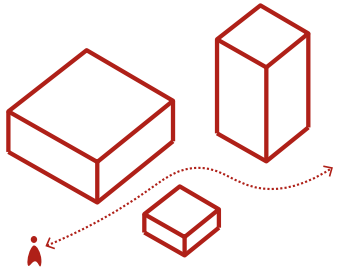
Complementary methods

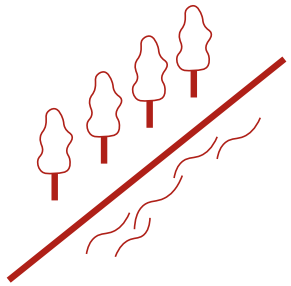
Site characterization:

Understand what is influencing the micro climate and how the space is used

Questionnaire:

Gain insight into the users' experience of local thermal conditions





Street level solutions: Intervention types

Tree(s)

Single tree, Ghent (BE)

- single tree
- row of trees
- group of trees

3-20 PET °C

Shelter Canopy

Shade sails, Amsterdam (NL)

- shade sail
- awning
- pergola

5-21 PET °C

Green Wall

Indirect green facade, Ardooie (BE)

- direct green façade
- indirect green façade
- living wall system
- free-standing green screen

1-6 PET °C

Water Feature

Fountain, Merelbeke (BE)

- fountain
- smaller waterway
- misting

0,5-6 PET °C

Cool Surface

Vegetated paving, Merelbeke (BE)

- grass
- vegetated paving
- damped pavement

0,5-2,5PET °C*

**measured at different heights*

Measurement results: Trees

Group of trees in Eeklo, BE

Species: Beech

Height: 10m | Crown Ø: 10m

Typology: Courtyard of a social centre

PET reduction: 19,9 °C

Row of trees, Saint Omer, FR

Species: Sweet chestnut | Orientation: NW-SE

Height: 20m | Crown Ø: 12m

Typology: pedestrian and cycling route

PET reduction: 18,1 °C

*3 out of 7 respondents would like **benches**, others would like facilities that allowed them to **stay longer***

Single tree, Kent, UK

Species: Norway maple

Height: 3,2m | Crown Ø: 1,5m

Typology: residential route

PET reduction: 12,8 °C

Lessons learned

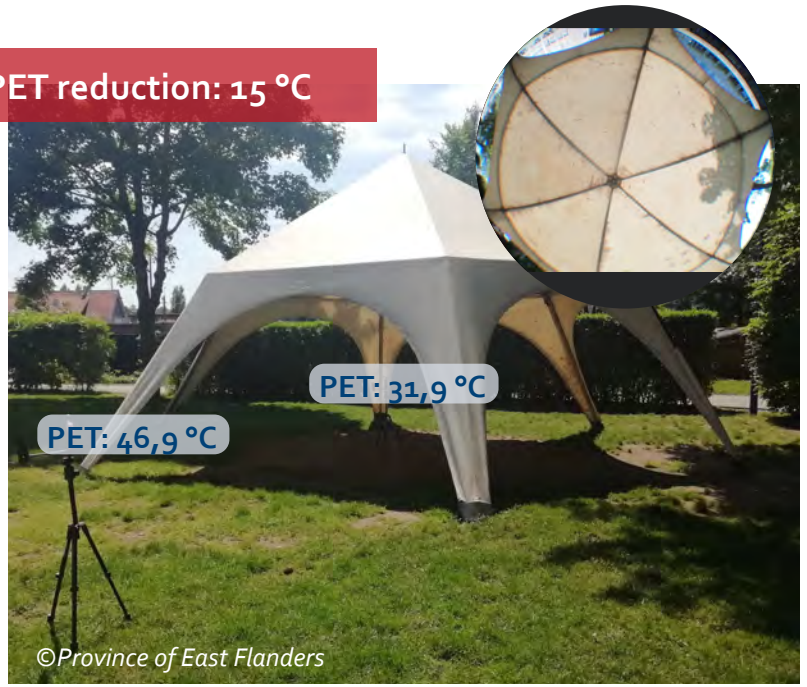
- Cooling capacity greatly depends on foliage cover
- Effective to reduce PET in public spaces for people to play, wait or stick around

Measurement results: Shelter canopies

Pergola, Middelburg, NL

Species: Wisteria

Typology: route near mobility hub



Shelter canopy, Zelzate, BE

Typology: school outdoor space

Social use : place to stay during the entire day

*most respondents mention the need for more **shelter and green***

Shade sail, Utrecht, NL

Typology: playground

Lessons learned

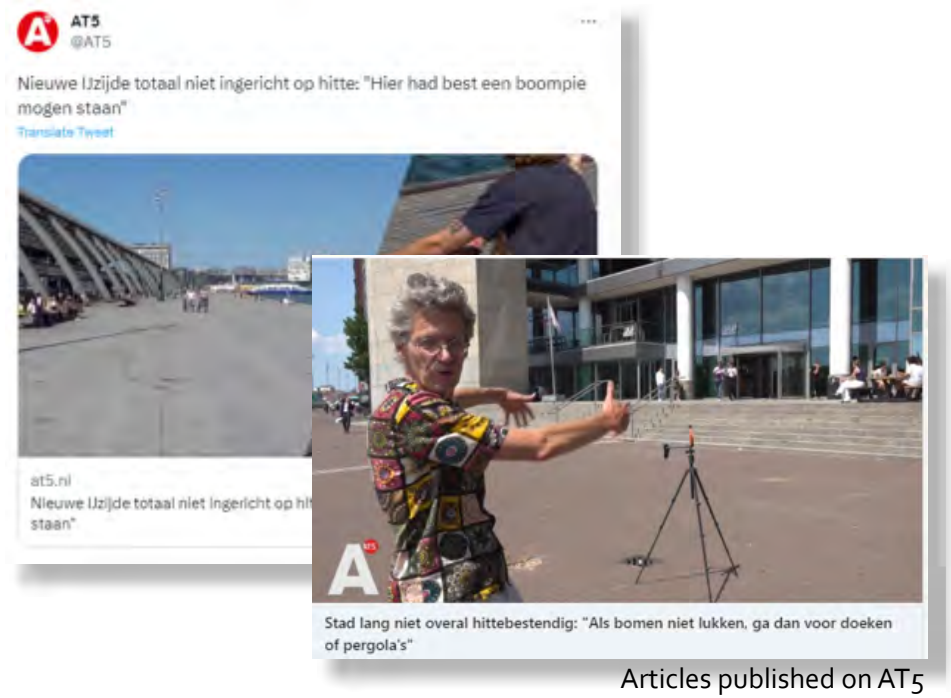
- Effectively reduces PET as it protects from direct solar radiation
- Quick adaptable to narrow streets with lack of space in city centres
- Provides an immediate solution to protecting vulnerable groups

Amsterdam University of Applied Sciences

Can pergolas offer a solution…?

- …as green solutions where trees are not (yet) possible?
- … when trees are not mature?
- … as building extensions to promote indoor and outdoor comfort?
- … as opportunities for experimentation & circular climate adaptation

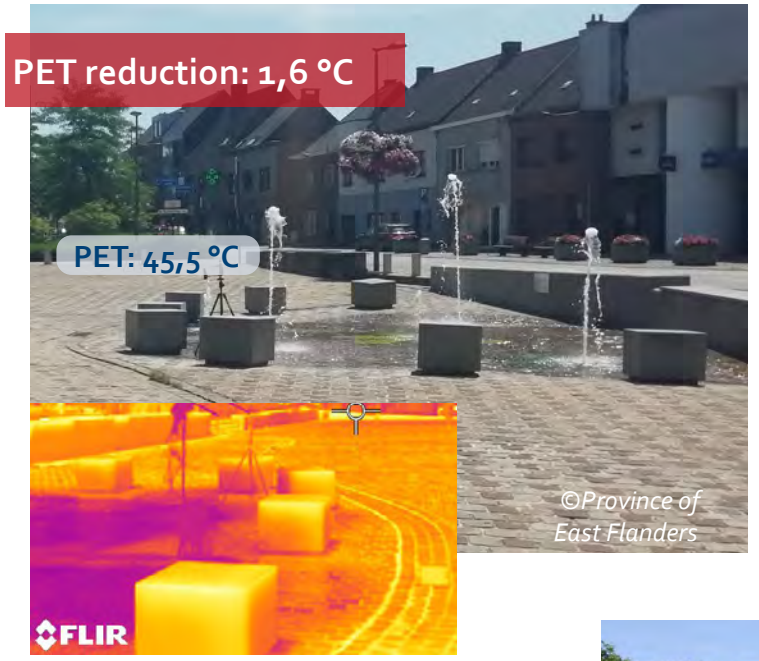
Experimental set-up at the Hogeschool van Amsterdam



Articles published on AT5

Would you like to get involved in this **outdoor lab***?*
Get in touch with Lisanne Corpel
l.a.corpel@hva.nl

Measurement results: Water features



Fountain, Merelbeke, BE

Typology: city centre

Land cover: ~90% paved surface

Small waterway, Breda, NL

Typology: city centre

Social movement: moderate pedestrian traffic & cycling route

Fountain, Gent, BE

Lessons learned

- Wind direction influences water vapour spread and thereby the cooling effect of fountains
- Co-benefits for recreation and biodiversity outweigh actual PET reduction benefits
- PET reduction is low near feature however, effectiveness depends on location

Measurement results: Green walls

PET reduction: 2,2 °C

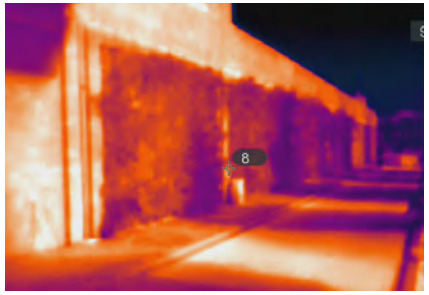
Living wall system, Merelbeke, NL

Species: mixed

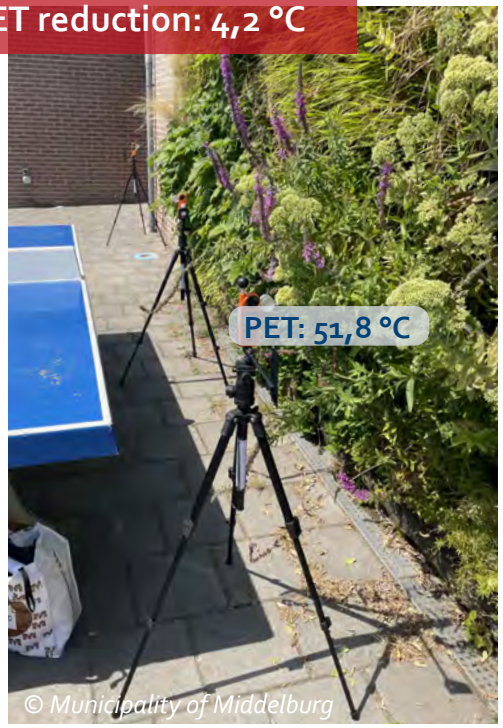
PET reduction: 2,0 °C

Direct green facade, Utrect, NL

Species: Chinese wisteria



PET reduction: 4,2 °C



Living wall system, Middelburg, NL

Species: mixed

Orientation: S

Green coverage: 100%

Typology: school outdoor area

Lessons learned

- The cooling effect of green walls is experienced when walking or sitting right next to them
- They are space efficient solutions to create cool walkingroutes or (Covid)waiting areas

Measurement results: Cool surfaces

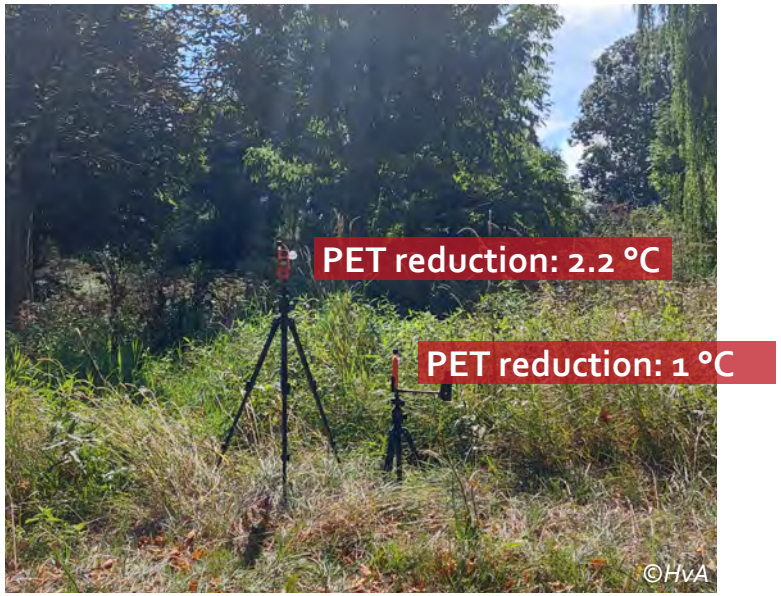
Effects on a city & local scale

Lessons learned

- Challenging to measure because sufficient surface area and distance between Kestrels are both required
- It does not provide significant PET reduction during daytime
- More efficient in mitigating the urban heat island effect

Asphalt (ref. point), Amsterdam, NL

Grass (height 22 cm), Amsterdam, NL



Grass (height 5 cm), Amsterdam, NL

Typology: city park

Measurement results: Cool surfaces

Effects on a city & local scale

- Effect on air temperature on city level
- Evaporation is the best way to cool the city
- Every 10 precent points of green leads to 0.5 °C cooling on city scale

Innovatielab Benno Premselahuis © Wieke Braat

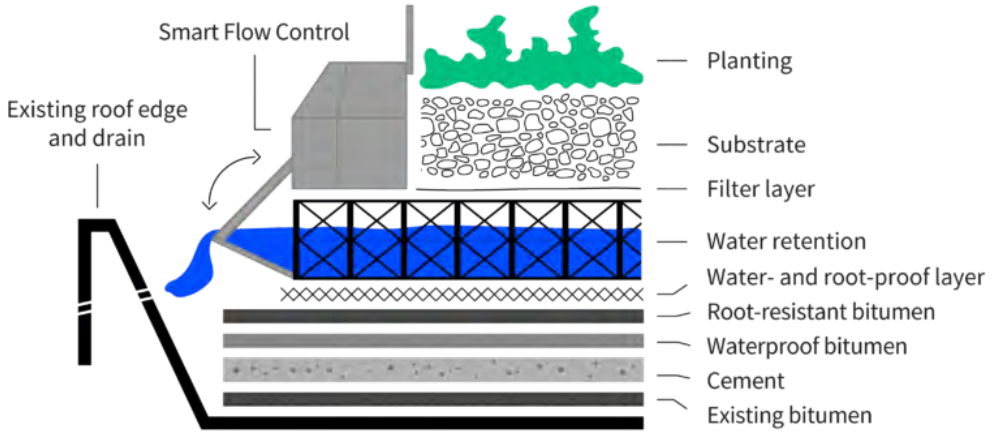
Cool surface example: Blue-green roofs

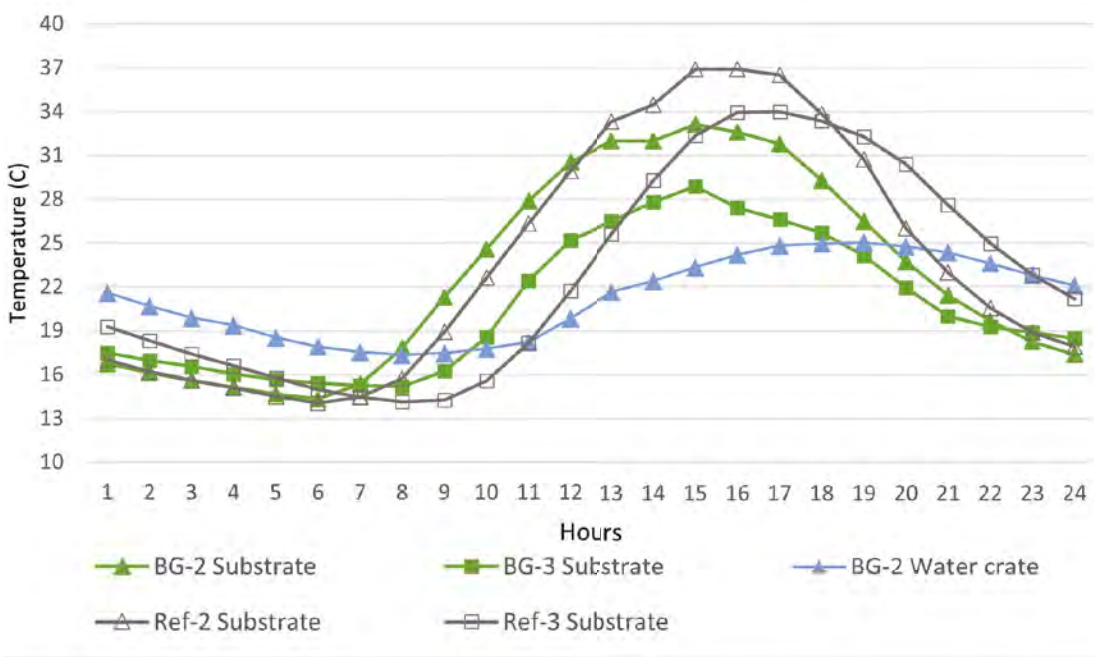
- During the warm periods, green surface on average 2-3 °C lower than gravel roofs
- Indoor temperature buffering effect

- The **city-wide effect** was estimated to be smaller or equal to **0,3 °C** at pedestrian level, with local variations up to 0,6 °C depending on the neighborhood typology.

27% of the total roof area was suitable for implementation of blue-green roofs, which translates to only 4,5% of the surface area of Amsterdam.

BG RESILIO-dak Makassarstraat/Javastraat © Wieke Braat





Coming up: The Cool Towns Intervention Catalogue

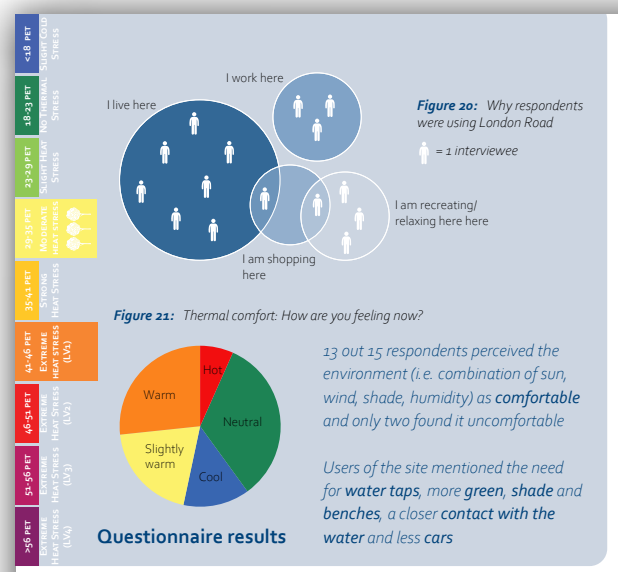


Figure 20: Why respondents were using London Road

Figure 21: Thermal comfort: How are you feeling now?

*13 out 15 respondents perceived the environment (i.e. combination of sun, wind, shade, humidity) as **comfortable** and only two found it uncomfortable*

*Users of the site mentioned the need for **water taps**, more **green**, **shade** and **benches**, a closer **contact with the water** and less **cars***

Questionnaire results

6.2.2 Row of silver lime trees in Breda

This site has a double row of 20 mature silver lime trees (Tilia tomentosa) forming an avenue with a pedestrian pathway between them. They are planted in grass and follow the southern side of the xxxx road in Breda, Belgium. There are trees on the other side of the road, which has speed-controlled traffic during the day, and the area is residential.

The effectiveness of these trees in mitigating heat stress was measured in mid-afternoon in early September when the air temperature was just above 250C. This is outside the date range stipulated in the Measurement Protocol, but all other conditions were met. A reduction in PET of 14.8 oC was measured between the shade of the trees and the reference point.

15 users of the area responded to the questionnaire and all but two of these reported respondents perceiving the environment (i.e. the combination of sun, wind, shade, humidity) as "comfortable" while the remaining two disagreed. When asked what would improve the area the need for drinking water points, more greenery, shade and benches, as well as closer contact with the water and less traffic.

Spatial characteristics

15 Mauritssingel, Breda, NL

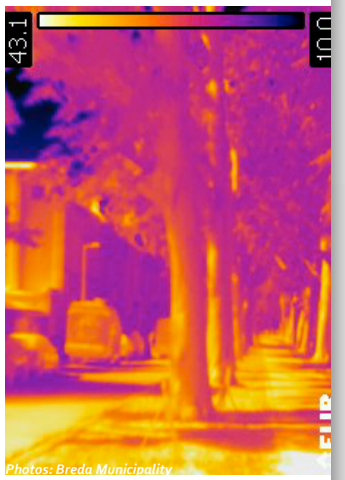
Spatial typology	Residential area
Blue-green infr.	20 mature trees, 150 m² grass, canal
Social use	Slow traffic route in use throughout the day

Row of trees

Date	7 September 2021
Time	14:29
dPET	14,8 °C PET reduction

Intervention characteristics

Species	Tilia tomentosa
Height	20 m
Crown Ø	15 m
Orientation	East-West
Ground	Grass
Condition	Healthy
Shape	Spreading



	PET (°C)	T_{air} (°C)	T_g (°C)	MRT (°C)	Wind (m/s)	RH (%)
Intervention	**29,5**	26,2	29,2	37,3	1,5	45,8
Reference	**44,3**	26,7	40,5	71,1	1,4	47
Difference	**-14,8**	-0,5	-11,3	-33,8	-0,04	-1,2

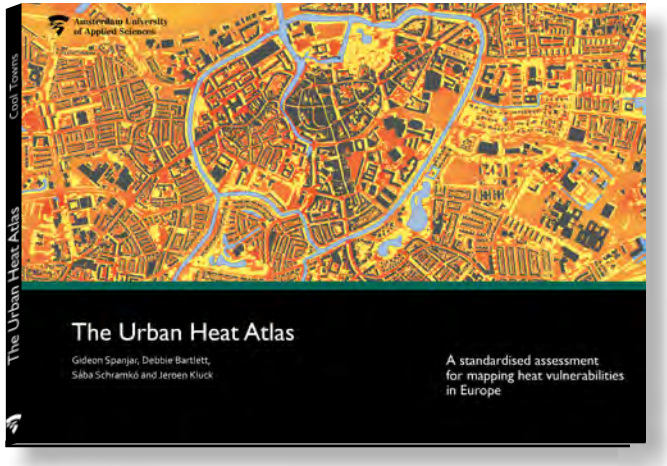
Int. grade	Moderate heat stress
Ref. grade	Extreme heat stress: Level 1

Measurements conducted by Gemeente Breda

Cool Towns Intervention Catalogue

Publishing in Autumn 2023

The Urban Heat Atlas



Download at: *research.hva.nl*

Nieuw land op het dak

Download at: *resilio.amsterdam*

Heat Stress Measurement Protocol

Download at: *research.hva.nl*

De hittebestendige stad

Download at: *research.hva.nl*

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