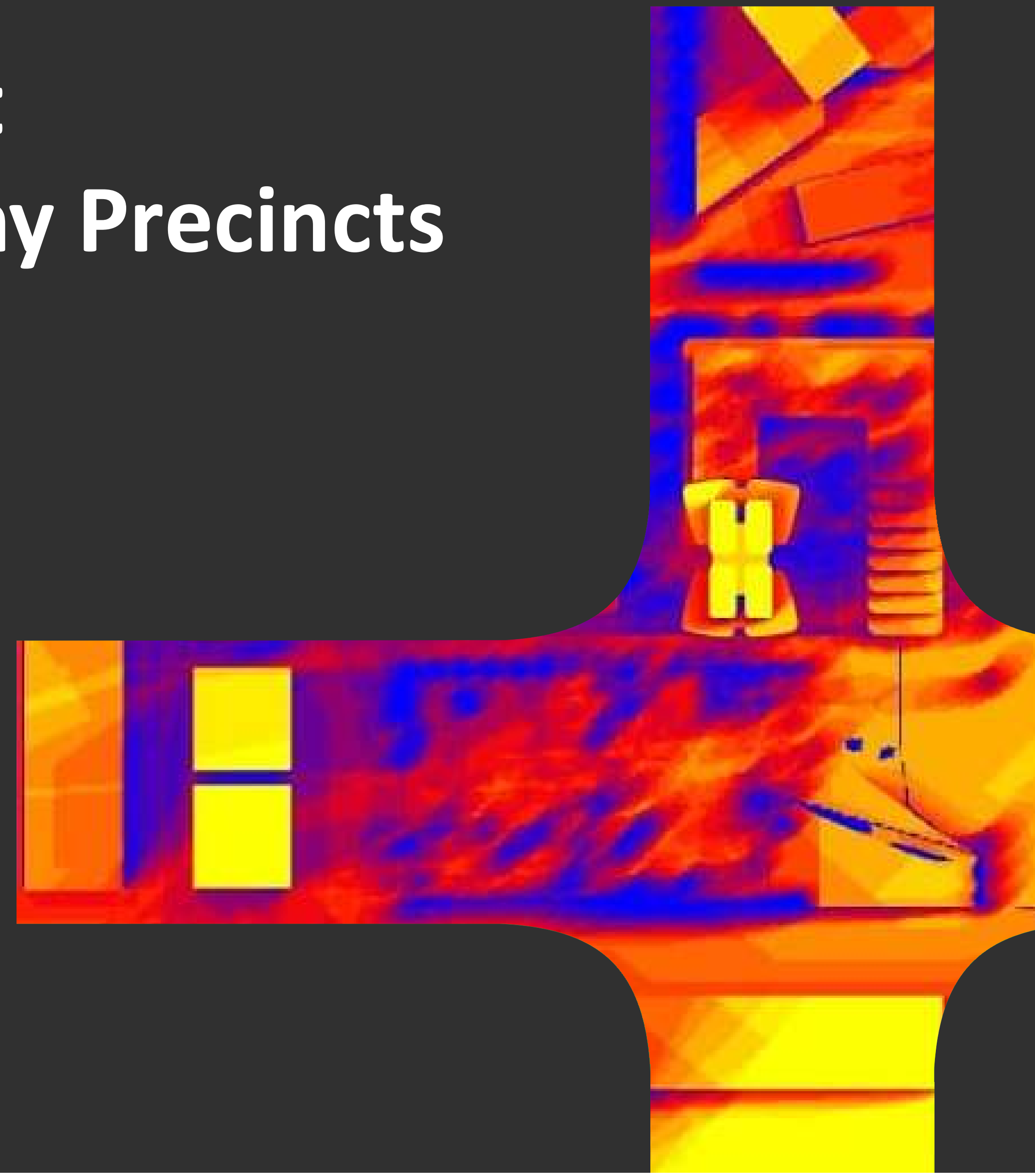
Urban Heat Island Effect
Digital Design for Healthy Precincts

CIBSE 12.08.2024



MOTT MACDONALD

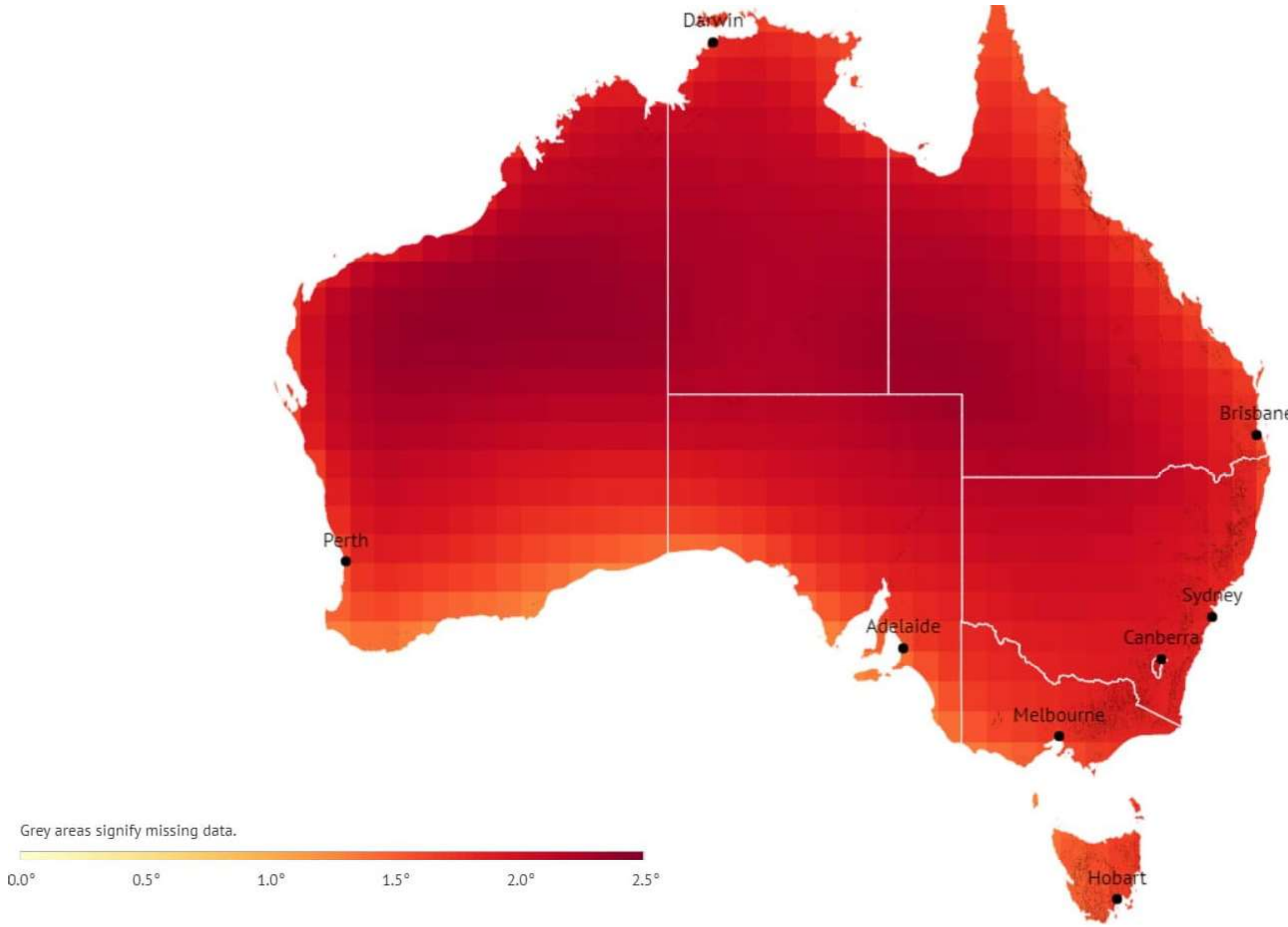

Urban Heat Island Effects
Climate change is increasing temperatures.
Cities need to adapt to reduce heat urban island effects.
Mott MacDonald | Precinct Design | Urban Heat Island Effect

Heatwaves & Unliveable cities

- Cities could become 'unbearable'
- Increase in death related to heatwaves
- Increase in energy consumption to cool buildings
- Water scarcity

Australia 2050 projections (IPCC)

RCP 8.5 predictions



Future temperature projections

Brisbane

2030

2090

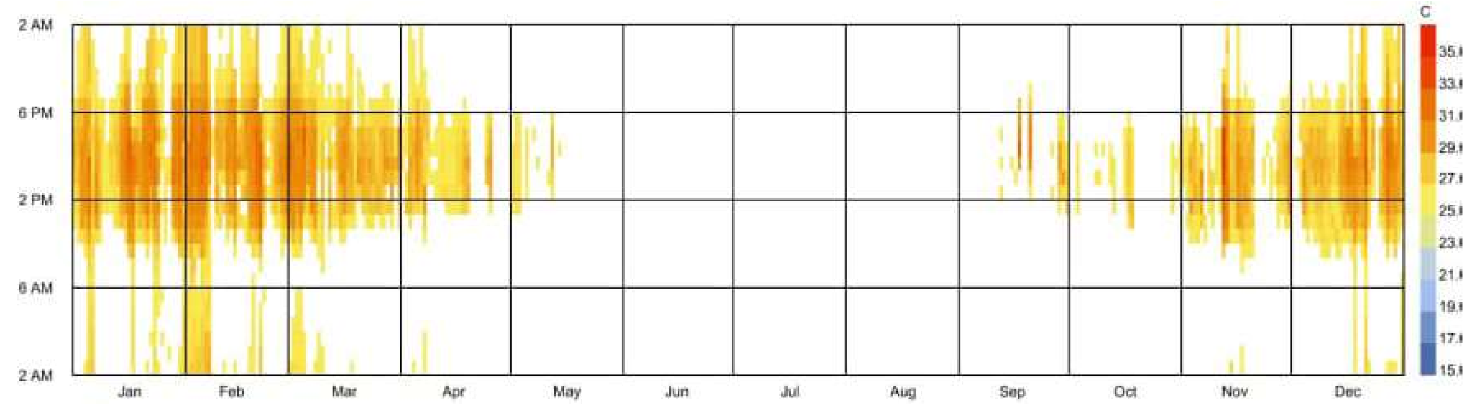


Figure 1.10 Annual Temperatures above 25 °C_ Current weather file

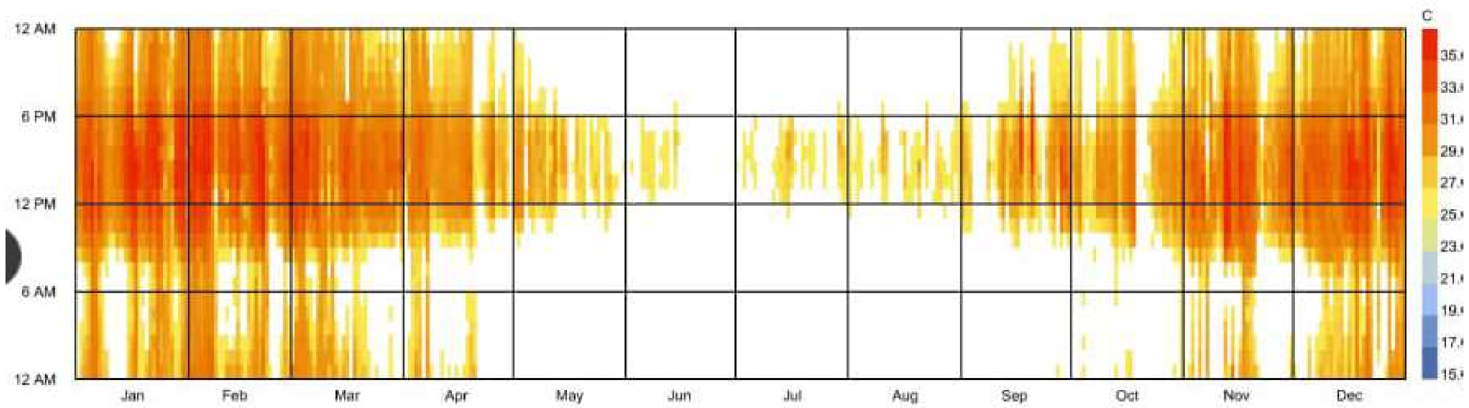
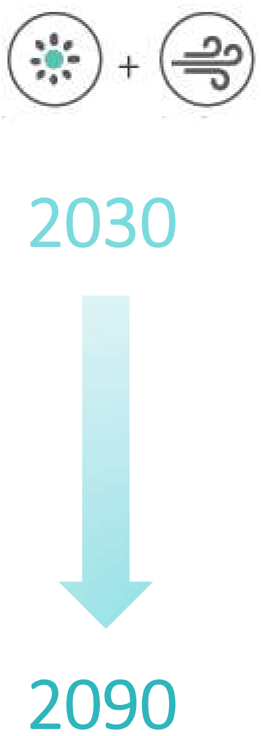


Figure 1.11 Annual Temperatures above 25 °C _ Predictive weather file 2090 (RCP 8.5)

Source: CSIRO_Predictive weather files for building energy modelling

Future thermal stress projections



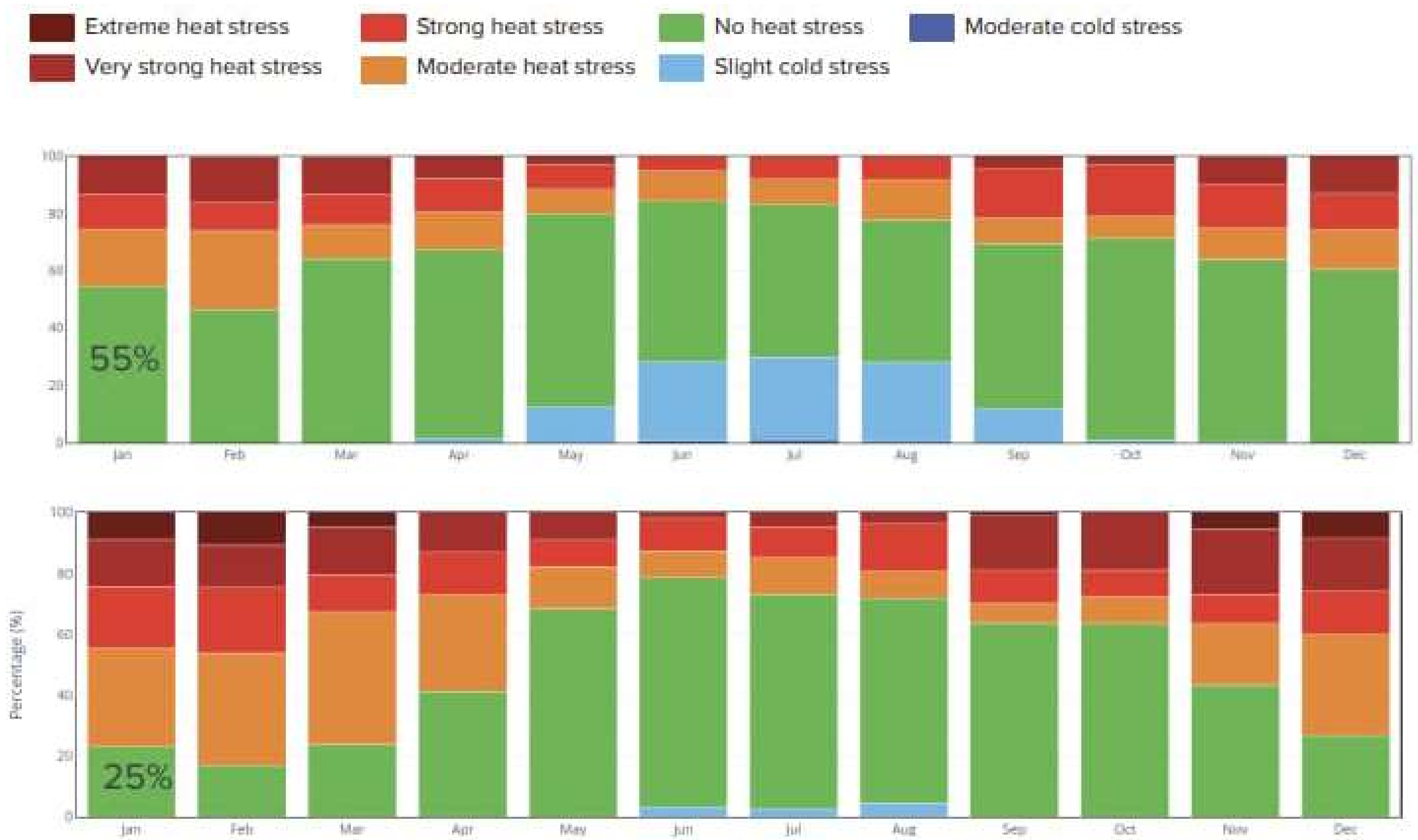


Figure 1.16 UTCI in Brisbane _ Predictive weather file 2090 (RCP 8.5) and Urban Heat Island Effect (Direct Sun and Wind)

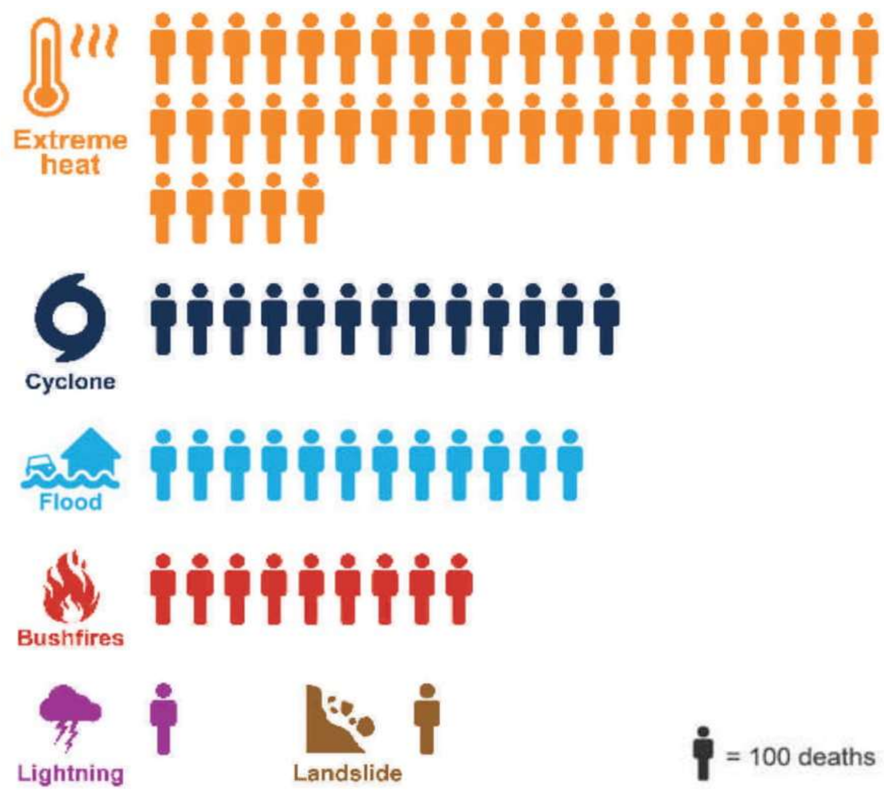
Source: CSIRO_Predictive weather files for building energy modelling

Death from natural hazards

- Deaths during a heatwave may be direct (heat illness) or indirect (heat exacerbating the effects of existing illness or vulnerability)
- From 1900 to 2010, extreme heat events have been
- responsible for at least 4,555 fatalities in Australia

Number of deaths

1900-2011

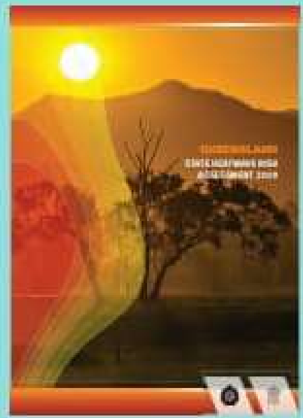


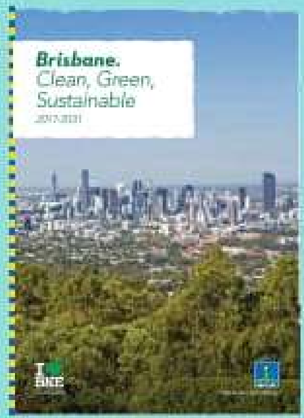
Source: Queensland State Heatwave Risk Assessment 2019

Background Research

- Review of local, national and global drivers
- Research of the existing knowledge on the topic and recent findings
- Coordination with universities to establish the bridge between the academia and the industry

Drivers





Walking during heatwaves

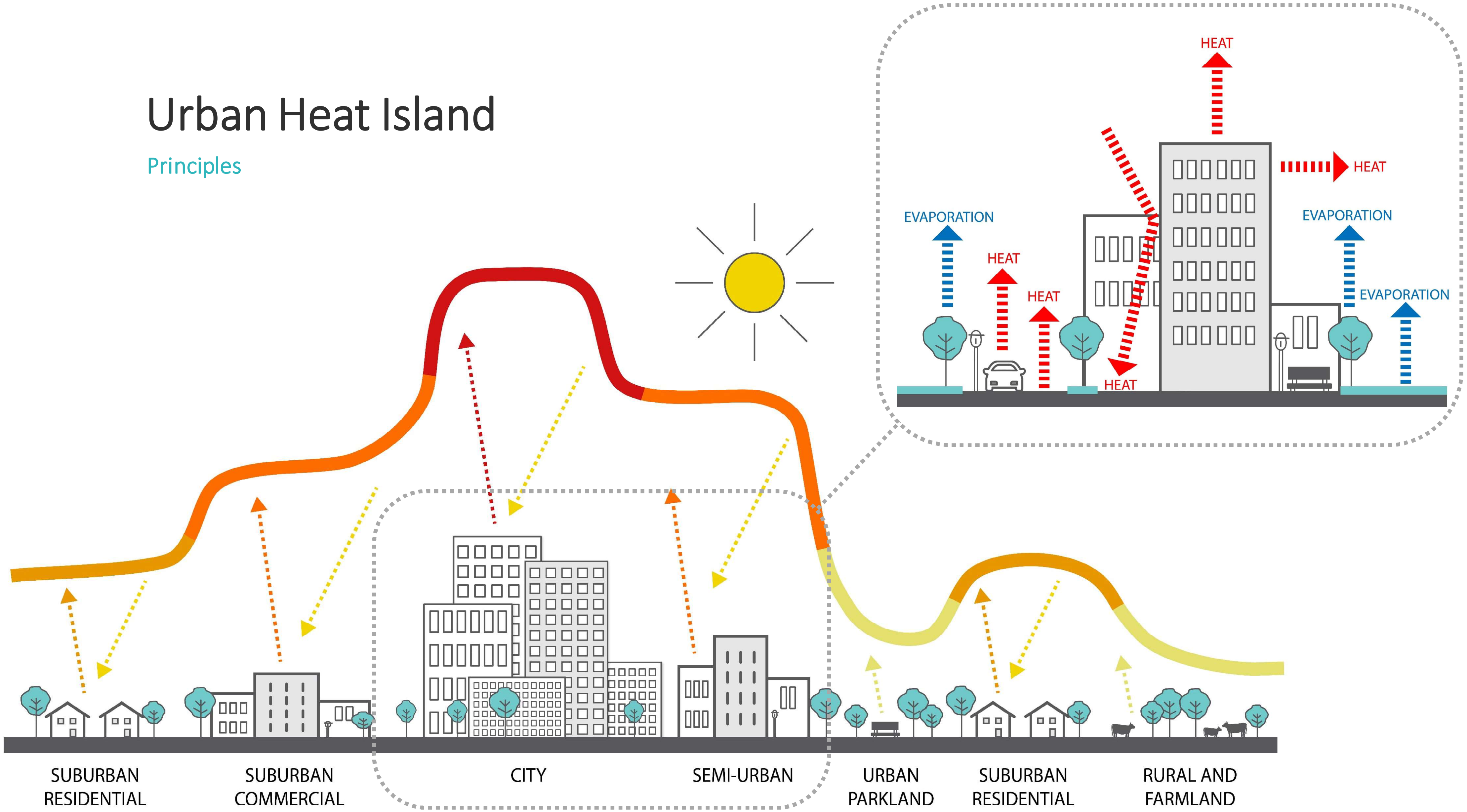
- Due to climate change, Melbourne is experiencing more hot weather and heat wave events than ever before
- Find the coolest routes through the city on hot summer days

Cool Routes tool

Image credits:
City of Melbourne Cool Routes tool
coolroutes.com.au

Urban Heat Island

Principles



Urban Heat Island Effect

What can increase temperatures in the Built Environment:

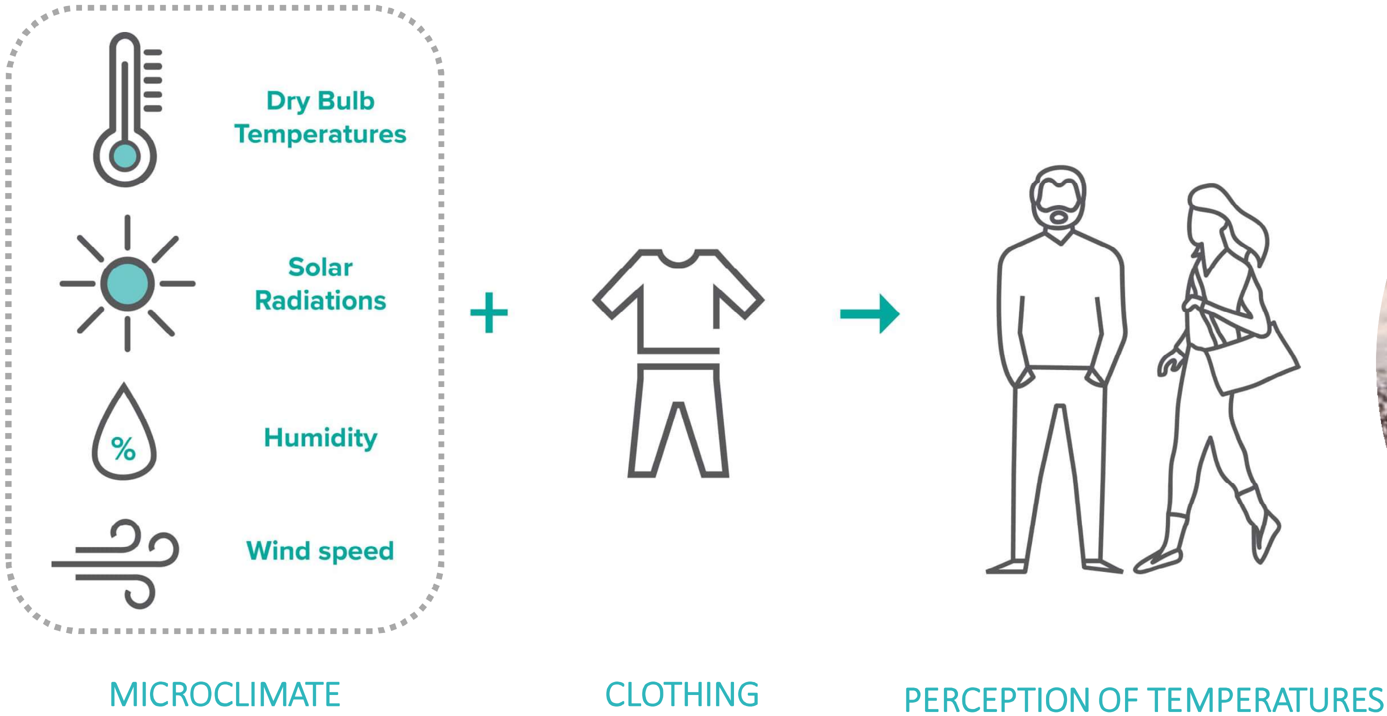
- Impervious surfaces
- Dark surfaces
- Lack of vegetation
- Heat rejection

Outdoor Thermal Comfort

Outdoor thermal comfort can be enhanced to improve health and wellbeing.

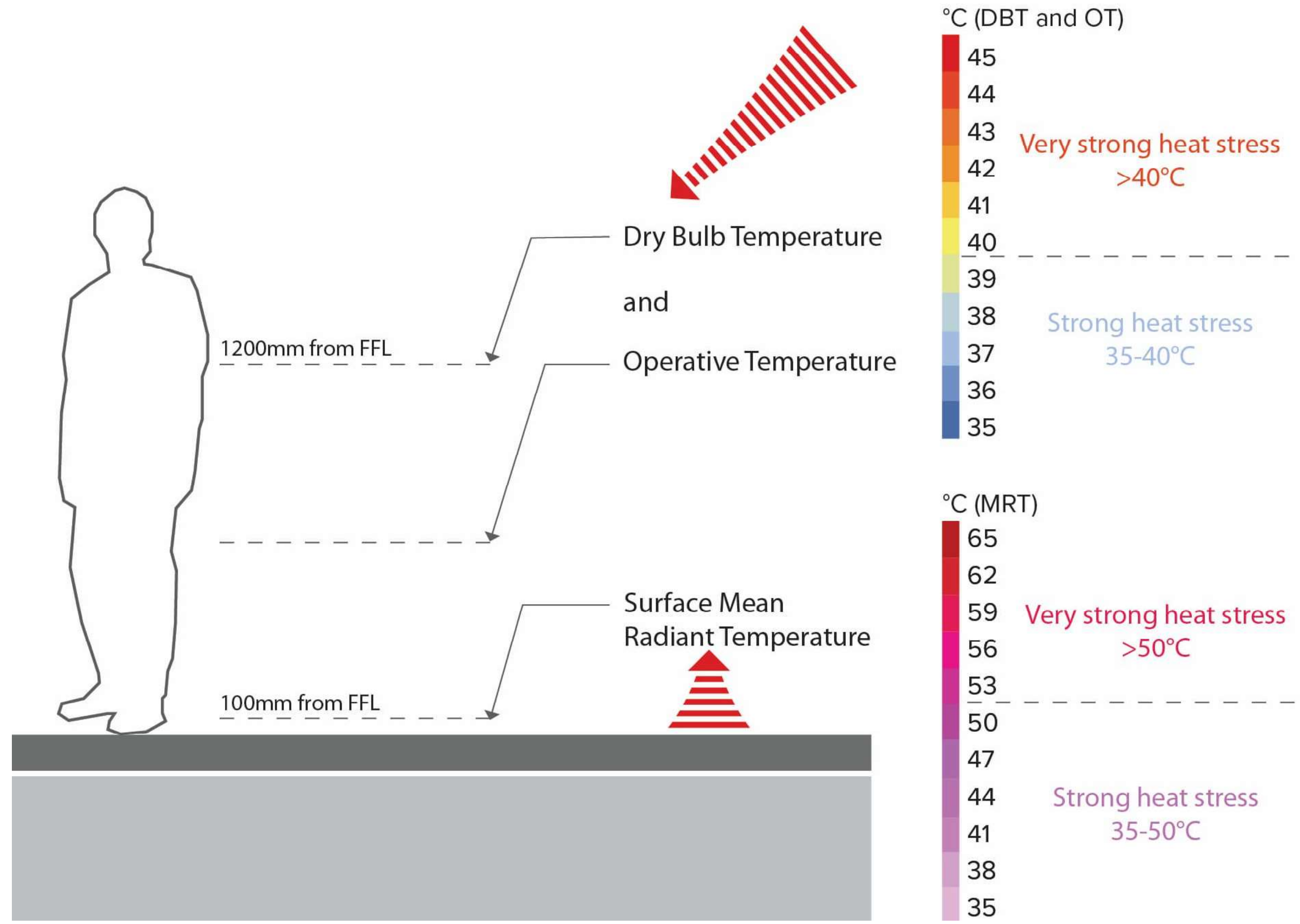
Outdoor Thermal Comfort

Principles

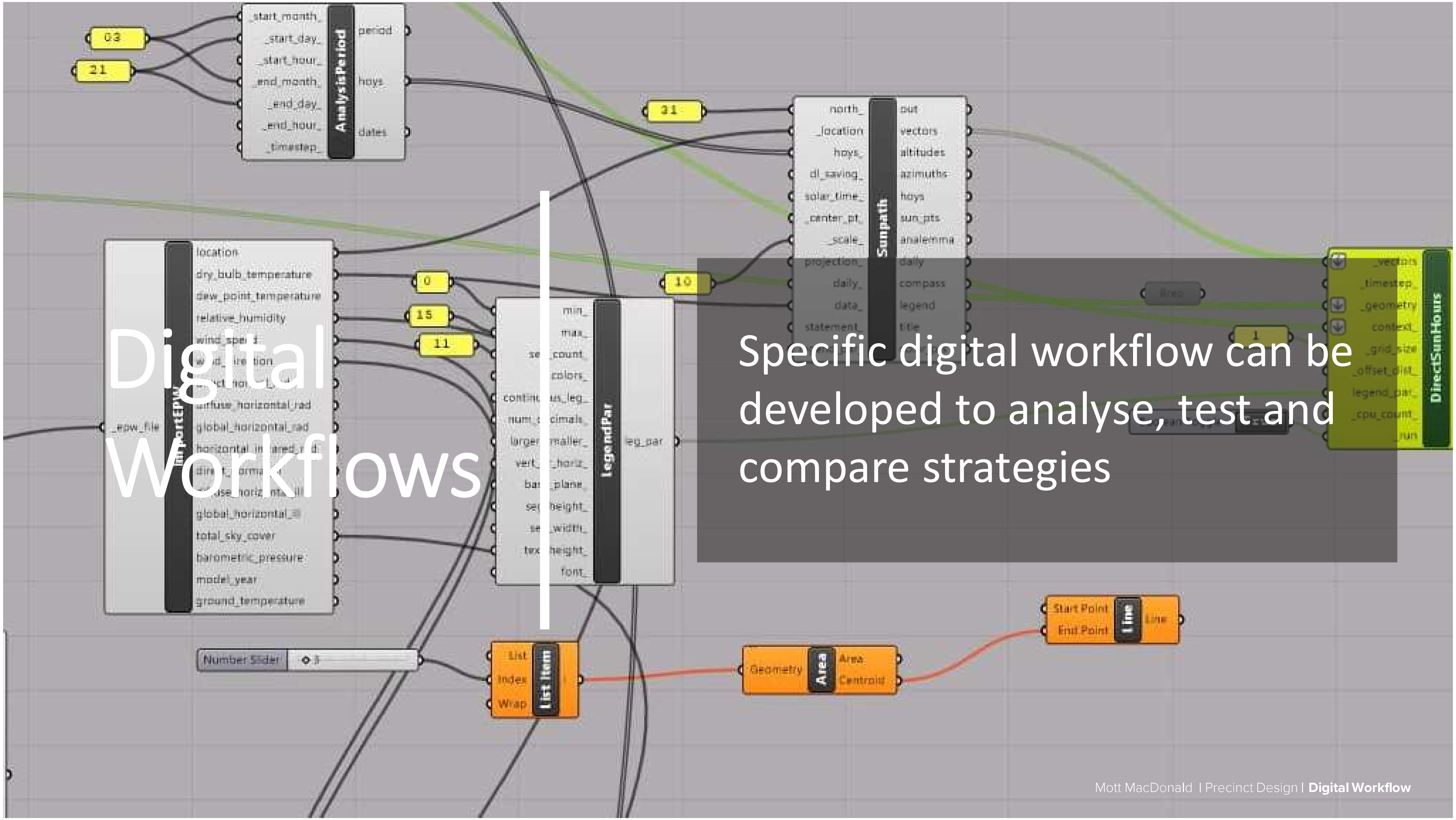


Temperatures & Solar radiations

- Define Operative Temperature by analysing Dry Bulb and Surface Mean Radiant Temperatures
- To understand perceived outdoor temperatures need to add the effects of wind, humidity and personal factors



Digital Workflows



Specific digital workflow can be developed to analyse, test and compare strategies

Digital Workflow & Simulations

Analysis related to Outdoor Thermal Comfort

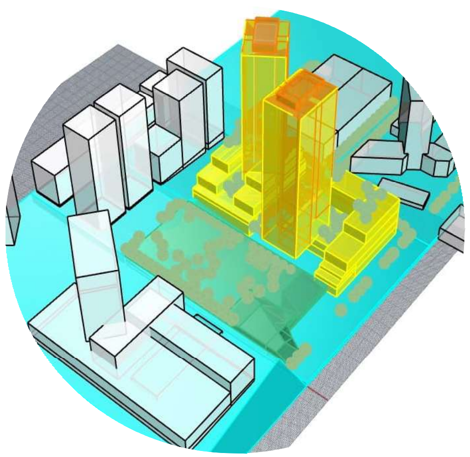
1
Urban Heat Island Effect

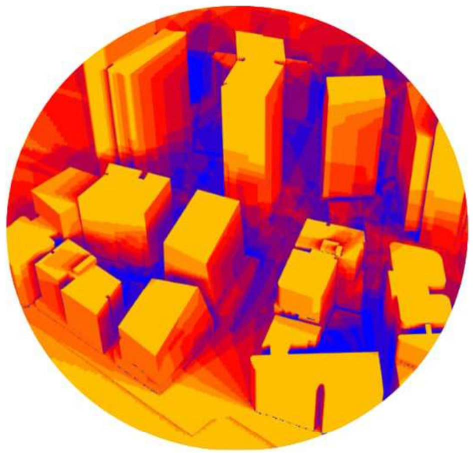
2
Sun hour analysis

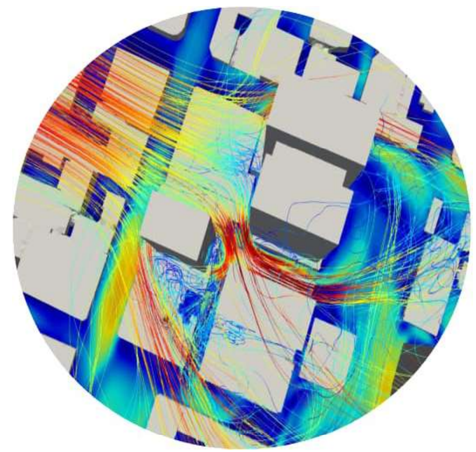
3
Mean Radiant Temperatures

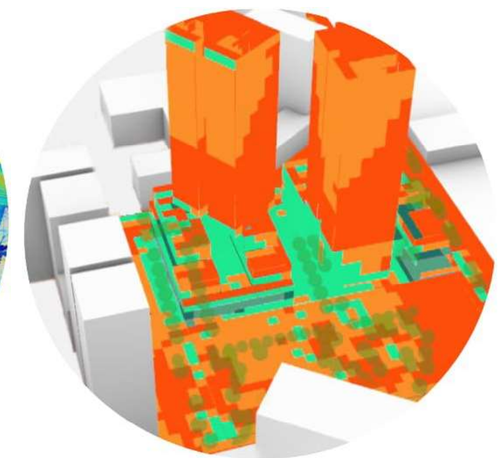
4
CFD analysis (Wind)

5
UTCI









Urban Heat

Outdoor Thermal Comfort

Sun Hours Analysis

View 1

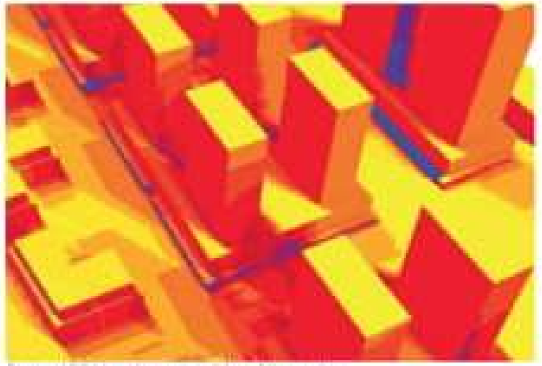


Figure 1.27 View 1 results _ 21st of December

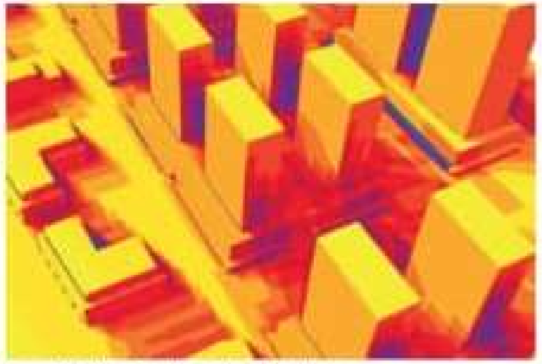


Figure 1.28 View 1 results _ 21st of September

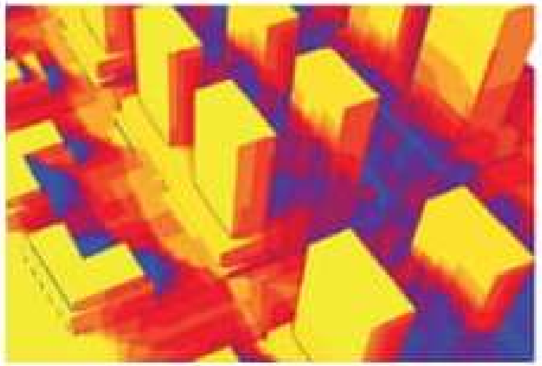


Figure 1.29 View 1 results _ 21st of June

View 2

Figure 1.30 View 2 results _ 21st of December

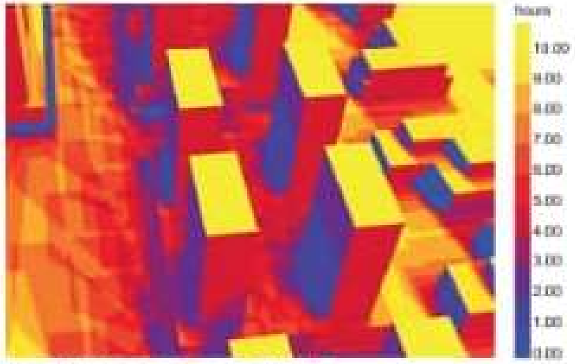


Figure 1.31 View 2 results _ 21st of September

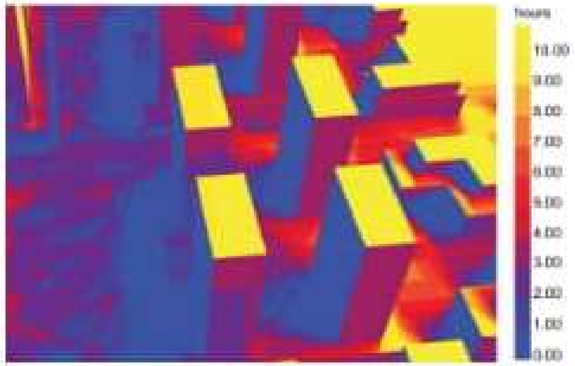
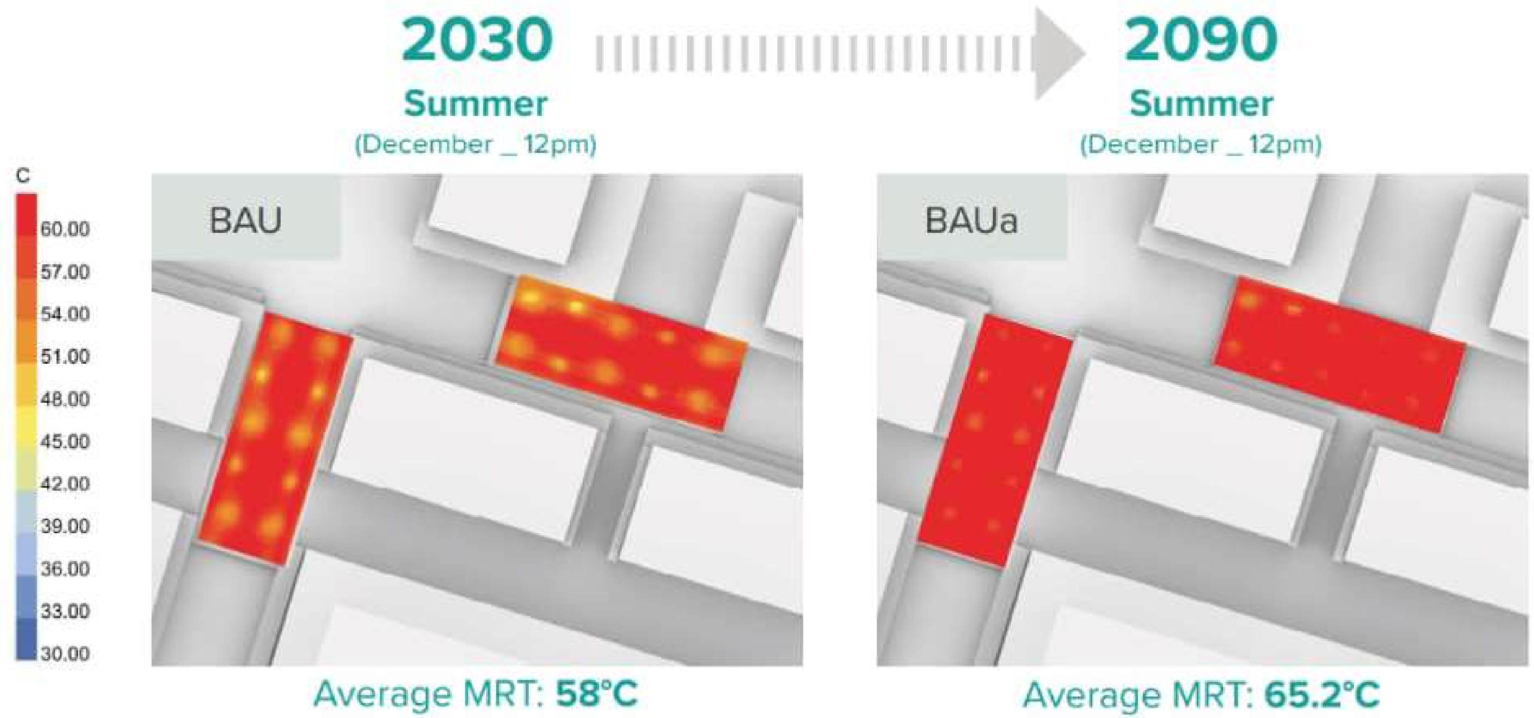


Figure 1.32 View 2 results _ 21st of June

Verify strategy impacts

- Assess MRTs of BAU design
- Compare current and future performance
- The simulation confirms increasing significantly increased MRTs across the site

Future projections Impact



Verify strategy impacts

- Proposed strategy is to increase tree canopy
- The simulation confirms increasing tree canopy significantly reduces MRTs across the site

Future projections Impact

Summer: Average surface MRT with **low** tree canopy: **65.2°C**

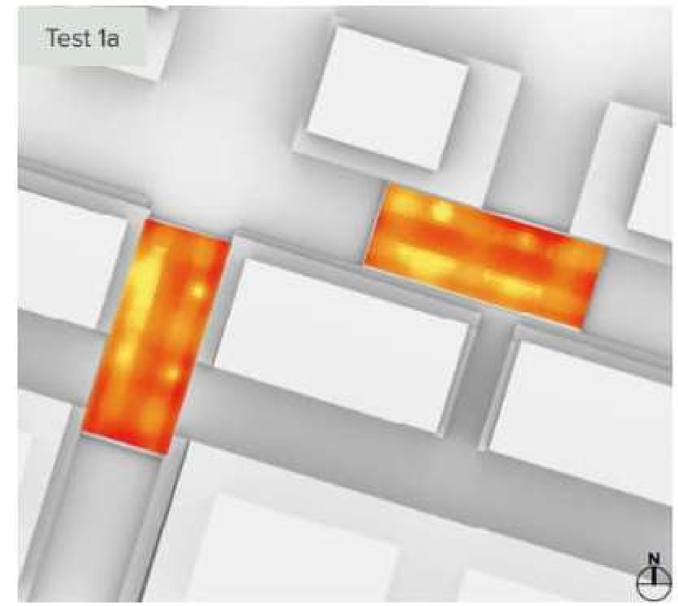
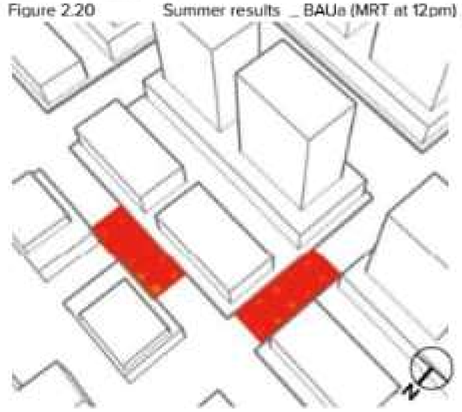
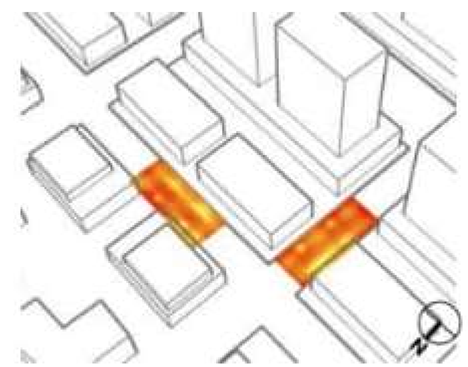


Figure 2.20 Summer results _ BAUa (MRT at 12pm)





Verify strategy impacts

- Compare ‘at completion’ scenario with young trees vs future projection with mature canopy
- The simulation confirms, that even with the increased future scenario temperatures, mature tree canopy significantly reduces MRTs across the site

Trees maturity testing

Test 5 with **young** trees (2030) _ Summer average surface MRT: **51.8'**

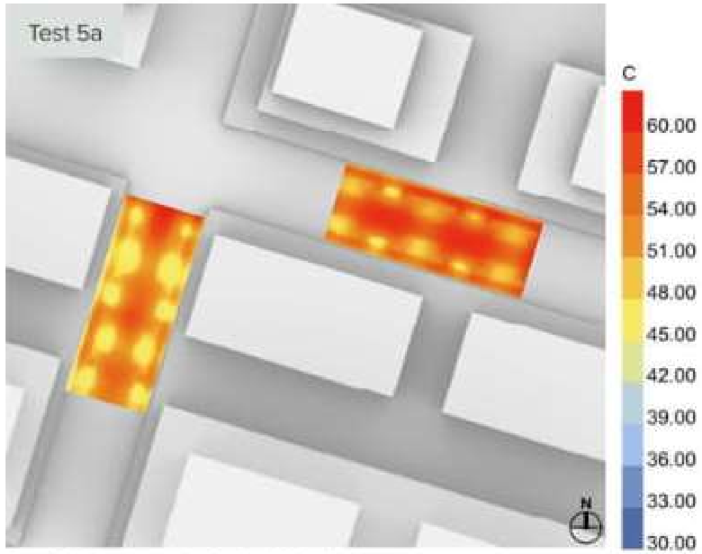


Figure 5.2 Summer results _ Test 5a (MRT at 12pm)

Test 5 with **mature** trees (2090) _ Summer average surface MRT: **44**

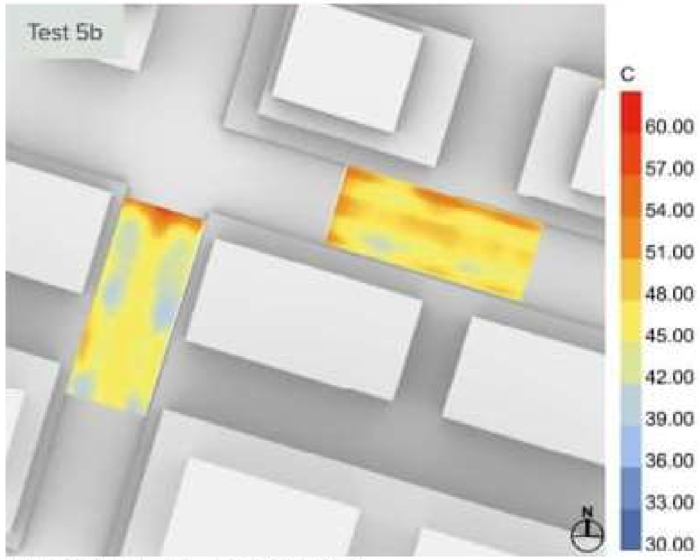


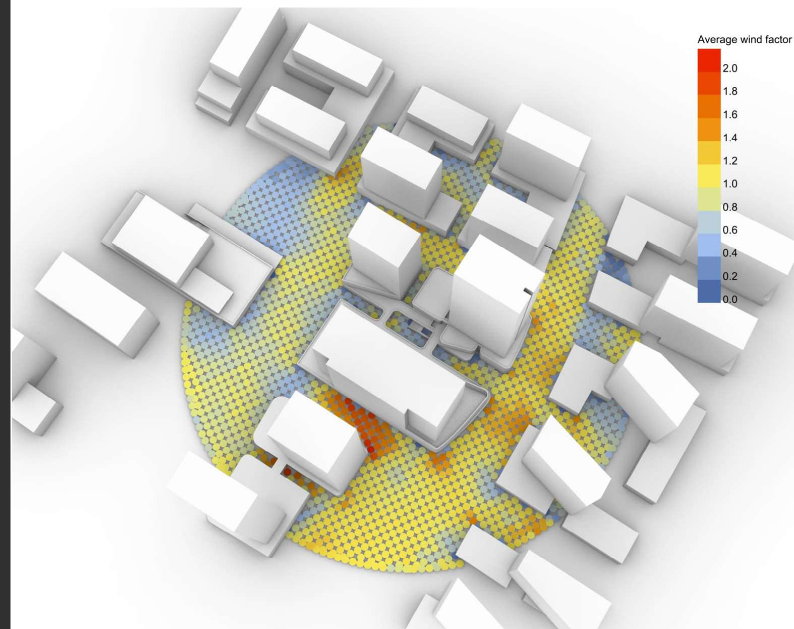
Figure 5.3 Summer results _ Test 5b (MRT at 12pm)

Verify impact of a strategy

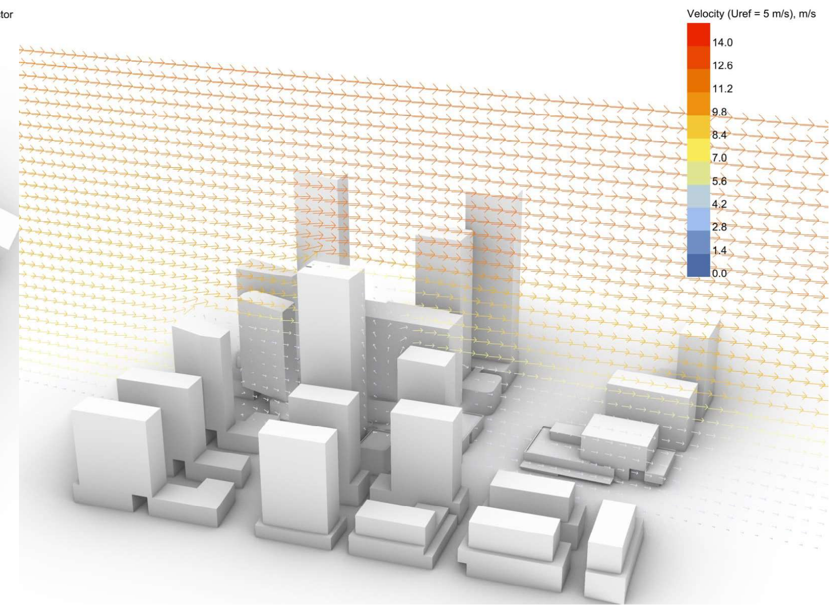
- Assess wind speed at different directions
- Identified issue is increased wind speed between towers
- Consider outdoor discomfort and potential for natural ventilation impacts

Impact of urban mass on wind factors

Wind factors



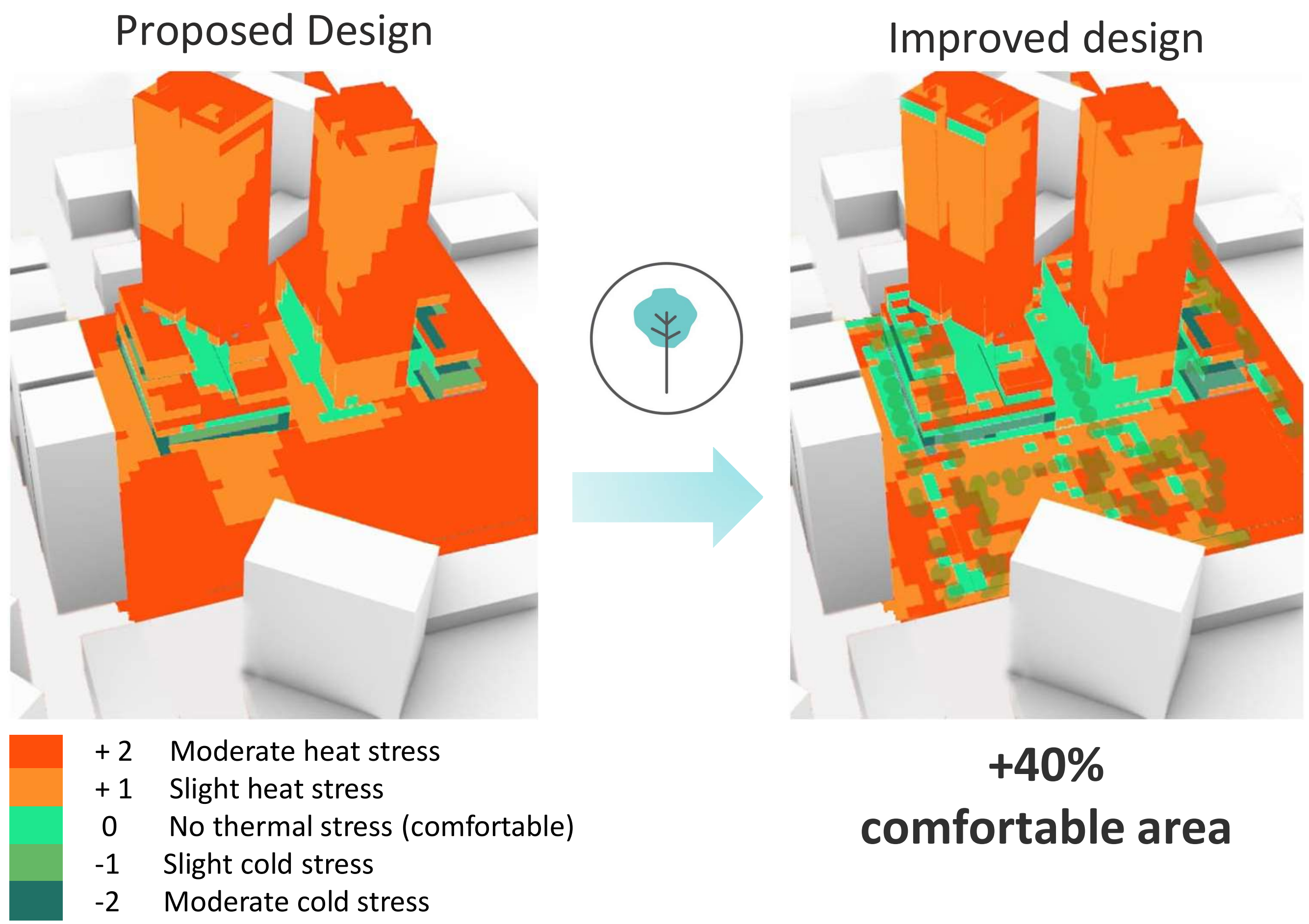
Vertical distribution



Verify strategy impacts

- Assess UTCI of a proposed project
- Proposed strategy is to increase tree canopy
- The simulation confirms adding trees can significantly reduce MRTs across the site
- Increase of low temperatures in some locations could mean the area is overshaded

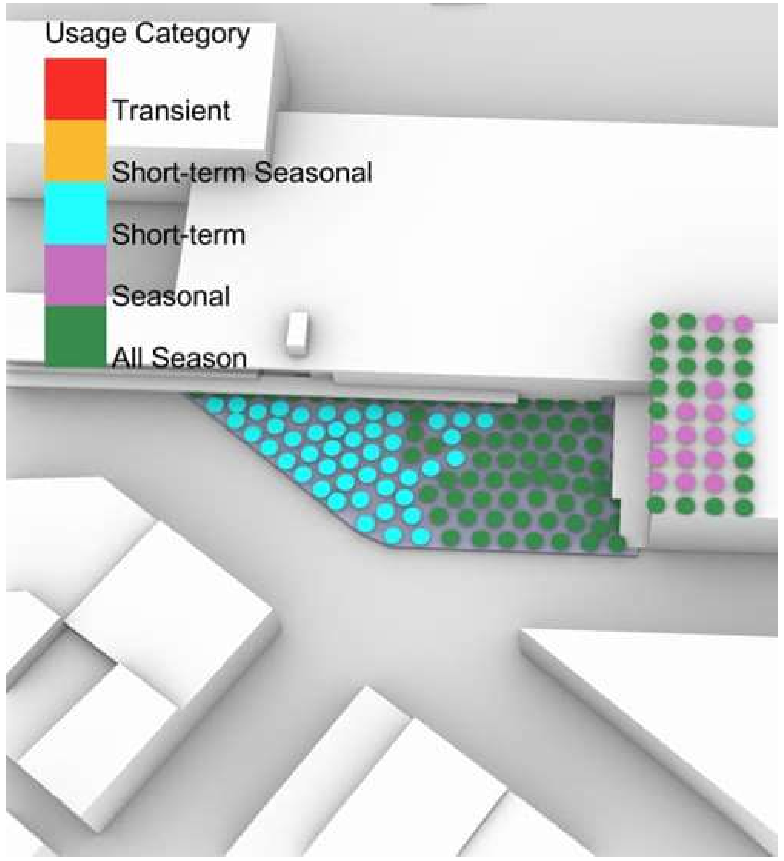
Impact of the tree canopy on UTCI



+40% comfortable area

Annual Comfort Category

Category	Acceptability	Description	Function examples
All seasons	>90% hours in each season	Year-round	• Parks and playgrounds • Al fresco dining areas
Seasonal	>90% hours mid-season; >70% hours in winter and summer	Most of the year	• Rooftops and podiums
Short-term	>50% hours in each season	Short term year-round	• Public transport waiting • Footpath
Short-term seasonal	>50% hours mid-season; >25% hours in winter and summer	Short term most year-round	• Bicycle lane
Transient	>25% hours mid-season; >25% hours in winter and summer	Transient	• Parking area

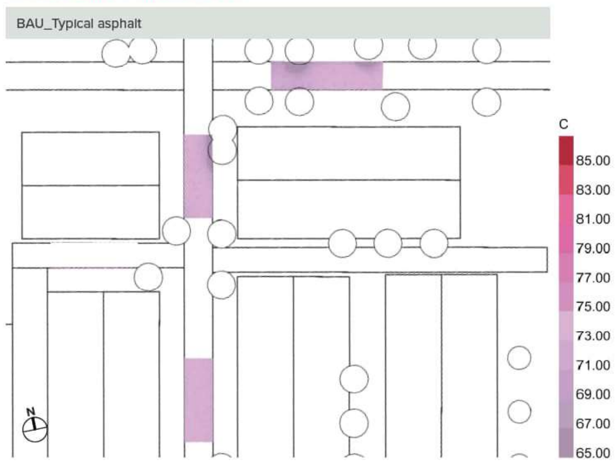


Optimised Precinct Design

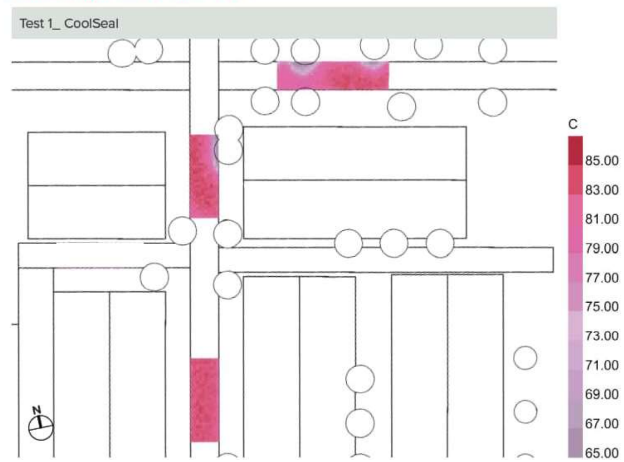
Using digital tools is the best way to verify the impacts of the proposed design and optimise thermal comfort.

Findings

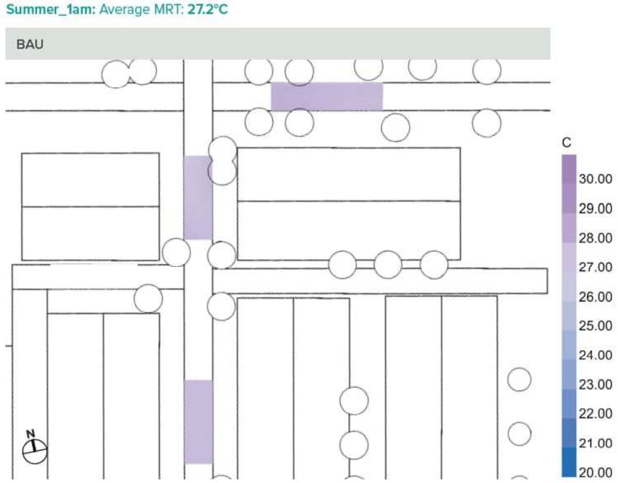
Summer_ 12pm: Average MRT: 69.9°C



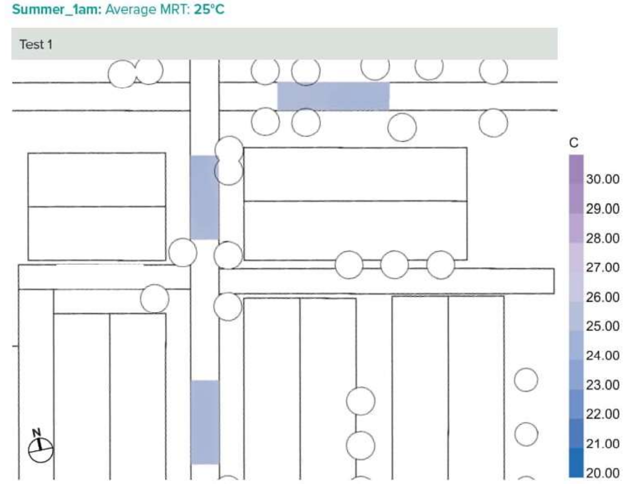
Summer_ 12pm: Average MRT: 77.4°C

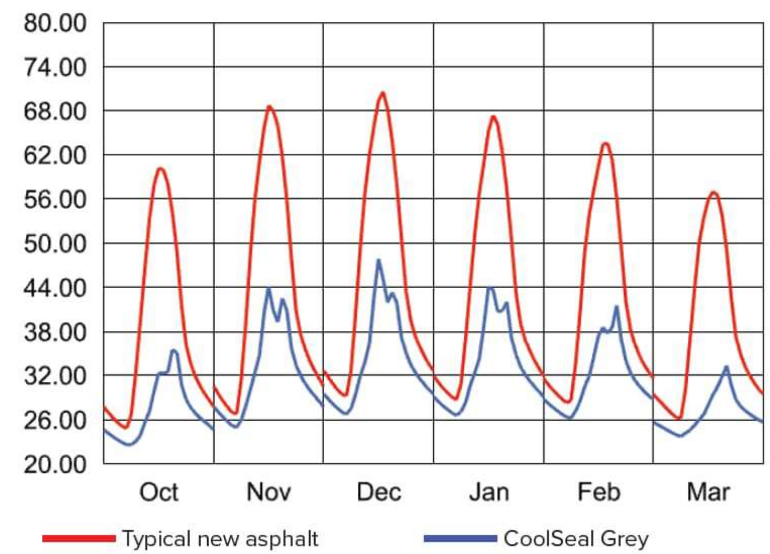


Summer_1am: Average MRT: 27.2°C

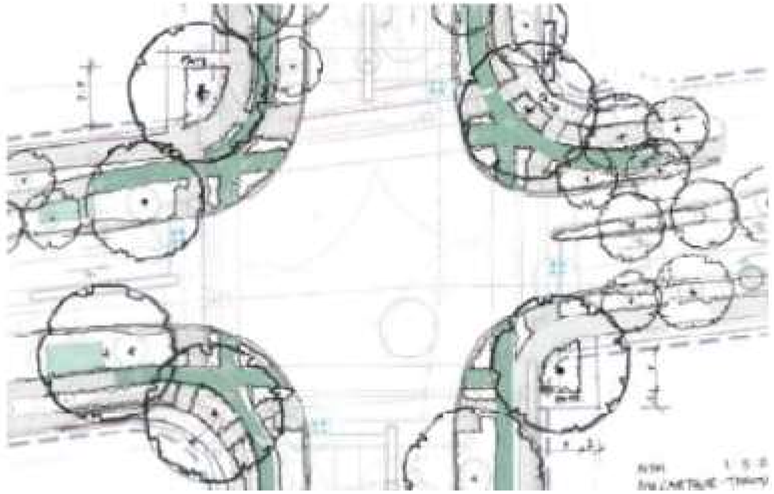


Summer_1am: Average MRT: 25°C



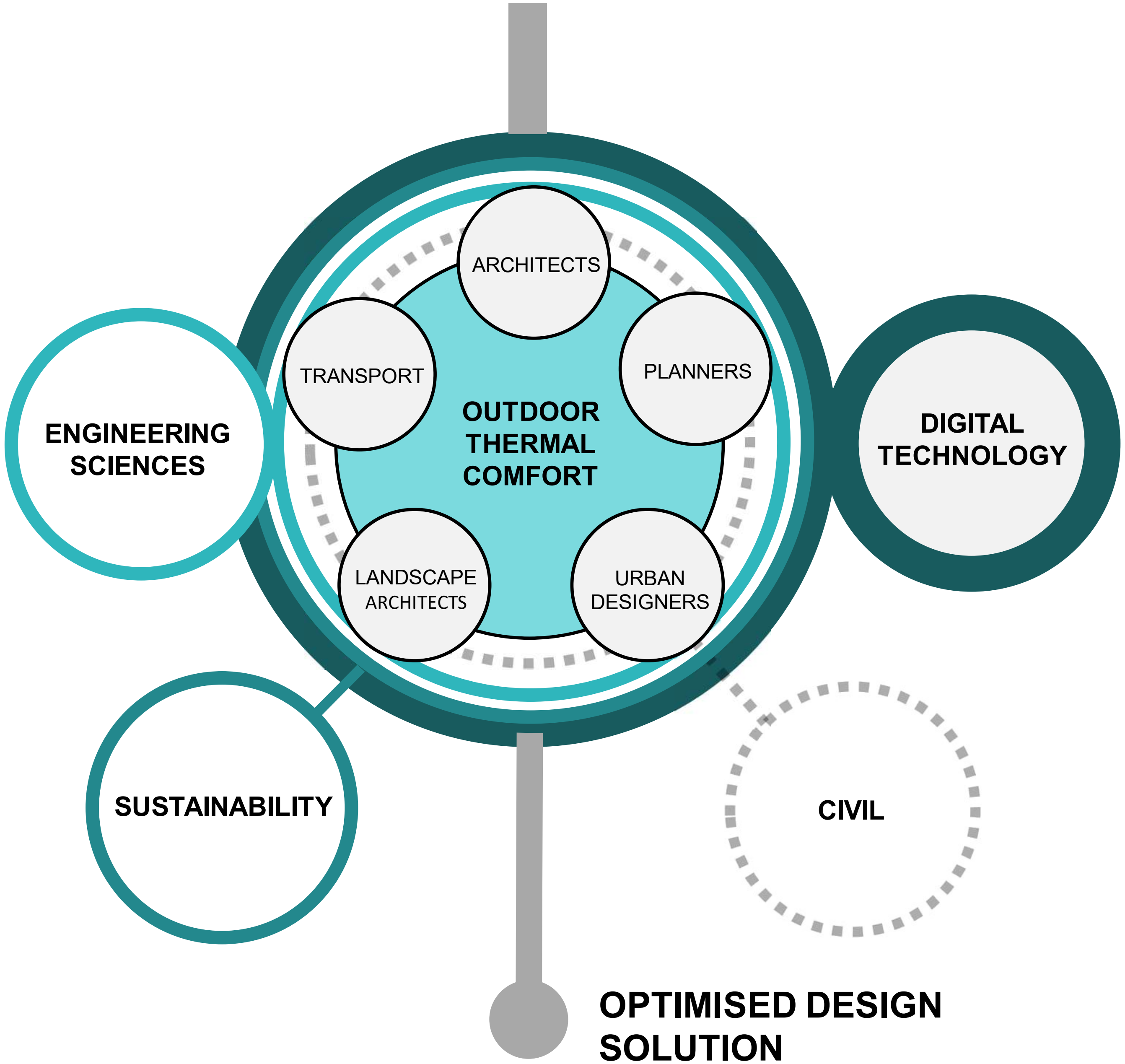


Design Interventions



Integrative Workflow

- All disciplines have impacts on outdoor thermal comfort
- Multi disciplinary integrative approach is needed
- Sustainability and Engineering Science help define, test and measure options
- Digital technology leads to better and faster decision-making



Time to act.

We are building now for the next 50 years and more.

Understand challenges.

Digital tools provide a better understanding of outdoor comfort.

Propose solutions.

Digital tools can test and quickly compare design options.

Design better.

Digital tools help in decision-making to achieve the best design outcomes.