



Annex 97-Sustainable cooling in cities- Assessment of human exposure to the outside environment

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BACKGROUND

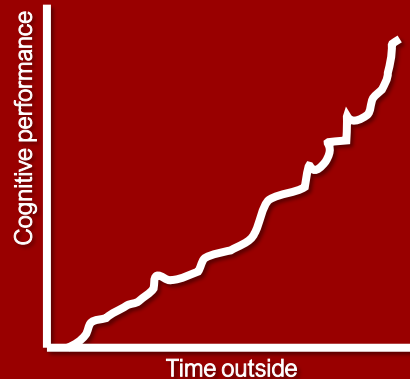
- Many types of people, during various activities, are exposed to the outdoor environment. People are exposed during transportation (train, bus, waiting area, platforms), during sports activities (spectators, athletes, leisure exercise), and outside work. (building and road construction, others).
- Cooling buildings can create a heat island.
- Buildings may reflect sunlight, causing glare and increasing radiant heat. Building ventilation and specific emissions from industrial buildings may create unacceptable outdoor conditions, such as odours or particles. Especially under extreme weather conditions, the exposures can be harmful (heat waves, forest fires).
- Therefore, there is a need to predict the exposure and assess the effects on health and comfort, not only under “normal” climate conditions but also under extreme ones (heat waves, heat islands, high wind speeds, etc)
- There are examples of attempts to create outdoor “cooled” spaces (shading, greenery, evaporative cooling, increased wind, etc.).

Here, it is important to predict local outdoor conditions and their effects on “occupants”

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Drivers for creating acceptable outdoor environments

- The number of heated/cooled/ventilated m² building per capita is increasing.
- New projects with "tiny houses" will lead to increasing interest in using outdoor spaces
- One hypothesis is that people spend more time in comfortable, attractive outdoor areas than in other parts of the city.
- A second hypothesis is that if people during the day get more exposure to daylight and the outdoor environment the work performance will increase
- Sustainable buildings certification programs (LEED, BREAM) also include some criteria for the outdoor



Sustainable buildings certification programs Urban Cooling Criteria

LEED V5 New construction (BD + C) (2026), USA

SITES V2 (2015), USA

Green Mark District V2.2, Singapore

Green Star Buildings V1, Australia

GB50378 (2006), China

BREEAM (2024), UK

DGNB (2023), German

CASBEE (2024), Japan

GRIHA (2022), India

HK-BEAM (Hong Kong 2021)

Most of the requirements/points are for including green plants, shading, and low reflective surfaces

Sustainable buildings certification programs

● Highly related (***) ● Related (**) ● Partially related / not covered (*)

Urban cooling criterion	LEED V5	SITES V2	Green Mark District	Green Star V1	GB50378	BREEAM (2024)	DGNB (2023)	CASBEE (2024)	GRHA (2022)	HK-BEAM (2021)
Heat island mitigation (surface reflectance & shading)	●	●	●	●	●	●	●	●	●	●
Vegetation & green cover	●	●	●	●	●	●	●	●	●	●
Outdoor thermal comfort assessment method	●	●	●	●	●	●	●	●	●	●
Wind environment assessment	●	●	●	●	●	●	●	●	●	●
Heat wave / extreme heat events	●	●	●	●	●	●	●	●	●	●
Evaporative / active cooling	●	●	●	●	●	●	●	●	●	●
Building orientation & massing	●	●	●	●	●	●	●	●	●	●
Climate resilience planning	●	●	●	●	●	●	●	●	●	●

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SCOPE

- Developing a set of KPIs will help city planners design spaces that are adequate for human occupation for a large part of the year, e.g. by planting trees to shade in the warm parts of the year and to break the wind in cold periods.
- In the literature, most KPIs deal with exposure to the thermal environment. There is a need to look at KPIs for other factors, such as air quality, noise, and light.
- Over 120 years of research on thermal indices are documented in the literature. It involves the perspectives of human thermal comfort and stress in both indoor and outdoor environments.
- The KPIs can be categorised into 3 types of indices: Rational index, Empirical index, and Direct index.
 - The rational indices are based on the human physiological model of heat exchange between the human and the surrounding environment.
 - Empirical indices used a multiple regression model to reflect human responses across environments and behavioural activities.
 - Direct indices emerge from the previous two types of indices, which are suitable for practical use through instrumental measurements

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Indicator	Standard	Variable
SET		v, RH, MET, T_{op}, Clo
PET		v, RH, MET, T_{op}, Clo
PHS		v, RH, MET, T_{op}, Clo
UTCI		H, T_{op}
WBGT		v, RH, T_{op}

Outside Top is calculated differently to indoor because of higher air velocity

What is H?

- Present the KPIs each on one slide
- Include limiting values
- Equations for WBGT, calculation WBGT from basic parameters

Operative temperature for Thermal Comfort Models and Predicted Heat Stress (PHS) where there are no limiting working hours

Standard and Categories	Upper Limit	Lower Limit
ISO 17772-1 Adapted		
Category I	30.7	19.1
Category II	31.7	18.1
Category III	32.7	17.1
ASHRAE Standard 55-Adapted		
80% Acceptability	31.7	17.4
90% Acceptability	30.8	18.5
ISO EN 7730 (ISO 17772-1)		
PMV limits ± 2	31.7	12.7
CLO	0.5	1.0
PMV limits ± 0.5 Cat. II	26.8	19.5
CLO	0.5	1.0

conditions clothing	Acclimatized		Non-acclimatized	
	Water Provided	Water Not Provided	Water Provided	Water Not Provided
0.5 clo	38.0	38.0	37.9	37.9
1.0 clo	36.2	36.1	35.0	35.0

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THE WALT DISNEY CONCERT HALL



1st & Grand Ave.



2nd & Grand Ave.



1st & Hope Street



2nd & Hope Street

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- KPI air quality, mainly particles
- KPI light reflection, glare, daylight therapy
- KPI Acoustic, sound level, noise from heatpumps