2.9.3 Physiological equivalent temperature (PET)

Project Name: UNaLab (Grant Agreement no. 730052)

Author/s and affiliations: Laura Wendling[1], Ville Rinta-Hiiro[1], Maria Dubovik[1], Arto Laikari[1], Johannes Jermakka[1], Zarrin Fatima[1], Malin zu-Castell Rüdenhausen[1], Peter Roebeling[2], Ricardo Martins[2], Rita Mendonça[2]

[1] *VTT Technical Research Centre Ltd, P.O. Box 1000 FI-02044 VTT, Finland*

[2] *CESAM – Department of Environment and Planning, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal*

Human Comfort: Physiological Equivalent Temperature (PET)	**Climate Resilience Natural and Climate Hazards**
Description and justification	Green urban infrastructure can significantly affect climate change adaptation by reducing air and surface temperatures with the help of shading and through increased evapotranspiration. Conversely, green urban infrastructure can also provide insulation from cold and/or shelter from wind, thereby reducing heating requirements (Cheng, Cheung, & Chu, 2010). By moderating the urban microclimate, green infrastructure can support a reduction in energy use and improved thermal comfort (Demuzere et al., 2014). The cooling effect of green space results in lower temperatures in the surrounding built environment (Yu & Hien, 2006).
Definition	Biophysiological equivalent temperature expressed in °C or °K according to international standard calculation method
Strengths and weaknesses	+ Compared to PMV, PET has the advantage to use °C, which allows the results to be easily interpreted by urban or regional planners - Requires extensive amount of data for evaluation
Measurement procedure and tool	To calculate PET (Höppe, 1999): 1. Determine the thermal conditions of the body using the Munich energy-balance model for individuals, MEMI, (1) for a given set of climatic parameters. MEMI is based on the energy balance equation of the human body and is related to the Gagge two-node model (Gagge, Stolwijk, & Nishi, 1972). The MEMI equation is as follows: $M + W + R + C + E_D + E_{Re} + E_{Sw} + S = 0$ (1) where, *M* is the metabolic rate (internal energy production by oxidation of food); *W* is the physical work output; *R* is the net radiation of the body; *C* is the convective heat flow; E_D is the latent heat flow to evaporate water into water vapour diffusing through the skin; E_{Re} is the sum of heat flows for heating and humidifying the inspired air; E_{Sw} is

	the heat flow due to evaporation of sweat; and, *S* is the storage heat flow for heating or cooling the body mass. As a first step, the mean surface temperature of the clothing (T_{cl}), the mean skin temperature (T_{sk}) and the core temperature (T_c) must be evaluated. These three parameters provide the basis for calculation of E_{Sw}. Two equations are necessary to describe the heat flows from the body core to the skin surface (F_{cs}) as shown in (2), and heat flows from the skin surface through the clothing layer to the clothing surface (F_{sc}) as shown in (3) (Höppe, 1999): $$F_{CS} = v_b \times \rho_b \times c_b \times (T_c - T_{sk}) \quad (2)$$ where, v_b is blood flow from body core to skin (L/s/m^2); ρ_b is blood density (kg/L); and, c_b is the specific heat (W/sK/kg). $$F_{CS} = (1/I_{cl}) \times (T_{sk} - T_{cl}) \quad (3)$$ where, I_{cl} is the heat resistance of the clothing (K/m^2/W). 2. Insert calculated values for mean skin temperature (T_{sk}) and core temperature (T_c) into the MEMI equation (1) and solve the three equations for air temperature, T_a (v☐= 0.1 m/s; water vapour pressure = 12 hPa; T_{mrt} = T_a). This temperature is equivalent to PET.
Scale of measurement	Building or plot scale
Data source	
Required data	Energy balance of the human body, heat flows though the body and clothing
Data input type	Quantitative
Data collection frequency	Annually, and before and after NBS implementation
Level of expertise required	High – requires ability to follow the calculation procedure and units, and to critically evaluate the results
Synergies with other indicators	Directly related to *Incorporation of environmental design in buildings* indicator
Connection with SDGs	SDG 3 Good health and well-being, SDG 11 Sustainable cities and communities, SDG 13 Climate action
Opportunities for participatory data collection	No opportunities identified
Additional information	
References	Gagge, A., Stolwijk, J.A., & Nishi, Y. (1971). An effective temperature scale based on a simple model of human physiological regulatory response. ASHRAE Transactions, 77(1), 247-257.

	Höppe, P. (1999). The physiological equivalent temperature – a universal index for the biometeorological assessment of the thermal environment. International Journal of Biometeorology, 2466, 71-75.

2.9.4 Predicted Mean Vote-Predicted Percentage Dissatisfied (PMV-PPD)

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Author/s and affiliations: Laura Wendling[1], Ville Rinta-Hiiro[1], Maria Dubovik[1], Arto Laikari[1], Johannes Jermakka[1], Zarrin Fatima[1], Malin zu-Castell Rüdenhausen[1], Peter Roebeling[2], Ricardo Martins[2], Rita Mendonça[2]

[1] VTT Technical Research Centre Ltd, P.O. Box 1000 FI-02044 VTT, Finland

[2] CESAM – Department of Environment and Planning, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

Mean or peak daytime temperature – Predicted Mean Vote-Predicted Percentage Dissatisfied	**Climate Resilience** **Natural and Climate Hazards**
Description and justification	Green urban infrastructure can significantly affect climate change adaptation by reducing air and surface temperatures with the help of shading and through increased evapotranspiration. Conversely, green urban infrastructure can also provide insulation from cold and/or shelter from wind, thereby reducing heating requirements (Cheng, Cheung, & Chu, 2010). By moderating the urban microclimate, green infrastructure can support a reduction in energy use and improved thermal comfort (Demuzere et al., 2014). The cooling effect of green space results in lower temperatures in the surrounding built environment (Yu & Hien, 2006)
Definition	Mean or peak daytime local temperature by PMV-PPD calculation (unitless value)
Strengths and weaknesses	+ Mathematical expression of a person's thermal comfort under indoor steady-state conditions - Subjective evaluation of thermal sensations - The output is **not** expressed in any temperature units, e.g., °C.
Measurement procedure and tool	The model aims to estimate the mean thermal sensation of a group of individuals and their respective percentage of dissatisfaction with the thermal environment, expressed in terms of Predicted Mean Vote-Predicted Percentage Dissatisfied (PMV-PPD). The practical