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Building-integrated photovoltaics: effect on the cooling load component of building façades

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The cooling load component of building-integrated photovoltaic (PV) walls has been investigated by numerical simulation of heat transfer across PV-walls. The cooling load component across the PV façades is predicted by the room transfer function method, based on the predicted heat gains for three cases at different locations (Beijing, Shanghai and Hong Kong). The simulation results are compared with the cooling load components of conventional walls that are directly exposed to the sun. The comparison indicates that the cooling load component reduction ratio due to photovoltaic integration ranges from 33% to 52% for a typical day in a year.

List of symbols

a, b Empirical coefficients of E (W/m^{2}K)
C_w specific heat of massive wall (J/kgK)
C coefficient of V_a
D depth of air duct (m)
D_w thickness of massive wall (m)
G net solar energy radiation absorbed (W/m^2)
E electric power rate generated by PV panels (W/m^2)
$F_{w\text{-}j}$ geometrical surface coefficient of the indoor surface of the PV-wall with respect to the north wall, east wall, west wall, ceiling and floor of the reference room
G total incident hourly solar radiation on a tilt surface (W/m^2)
h_{cgo} convective heat transfer coefficient on the front surface of the PV panels (W/m^{2}K)
h_{cgi} convective heat transfer coefficient on the back surface of the PV panels (W/m^{2}K)
h_{rgo} radiant heat transfer coefficient on the front surface of PV panels (W/m^{2}K)
h_{cwi} convective heat transfer coefficient on the inside surface of massive wall (W/m^{2}K)

Greek symbols

α_n composite heat transfer coefficient of heat convection and radiation (W/m^{2}K)
β slope of tilted surface ($\frac{\pi}{2}$ for a vertical wall)
ϕ latitude of surface location
λ_w thermal conductivity of massive wall (W/mK)
v_o transfer coefficient from ASHRAE[1]
v_1 transfer coefficient from ASHRAE[1]
v_2 transfer coefficient from ASHRAE[1]
ω hour angle
ω_1 transfer coefficient from ASHRAE[1]
ρ_g reflectance of surroundings, usually 0.2
ρ_w density of the massive wall (kg/m^3)
θ angle of incidence on a tilt surface
θ_z angle of incidence on a horizontal surface
$(\tau\alpha)$ product of transmittance and absorptance

Subscripts

b beam or balance point
d diffuse

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