SUPPLEMENTARY MATERIAL

The photon flux emitted by a blackbody of temperature T over the restricted energy range from E_i to E_j is

$$\dot{N}(E_i,E_j,T,\mu,\theta) = \theta\frac{2\pi}{h^3c^2}\int_{E_i}^{E_j}\frac{E^2}{exp\left(\frac{E-\mu}{kT}\right)-1}dE \qquad \text{(S1)}$$

where h is Planck's constant, c is the speed of light, k is Boltzmann's constant, θ is the projected solid angle subtended by the radiation source, and μ is chemical potential. The maximum current (I) extractable from a PV cell is the difference between the current pumped to the conduction band by photon absorption, and the current associated with luminescent emission:

$$I/q = \dot{N}_S - \dot{N}_R = a\dot{N}(E_g,\infty,T_S,0,\theta_S) - \varepsilon\dot{N}(E_g,\infty,T_c,qV,\theta_{em}) \qquad \text{(S2)}$$

where q is the elementary charge, $\dot{N}_S$ and $\dot{N}_R$ are the current contributions associated with photon absorption and emission, a and ε are the absorptivity and emissivity of the cell, E_g is the bandgap energy, T_S and T_c are the respective temperatures of the sun and the cell, V is the applied voltage, and θ_S and θ_{em} are, respectively, the projected solid angles subtended by the sun and cell emission (with the contribution of the background blackbody radiation from the environment being neglected here).

In the radiative limit[S1]

$$\eta_{PV} = \frac{\{qV[\dot{N}_S(\mu=0) - \dot{N}_R(\mu=qV)]\}_{max}}{P_{in}} \qquad \text{(S3)}$$

where P_{in} is the incident solar flux, and the radiative limit refers to

1. each absorbed photon generating one and only one electron-hole pair,
2. no absorption of sub-bandgap photons,
3. the only loss mechanism being radiative recombination,
4. negligible resistive losses, and
5. the cell being maintained at ambient temperature (taken here as 300K).

S1 A. S. Brown and M. A. Green, *Prog. Photovolt: Res. Appl.*, 2002, **10**, 299-30.