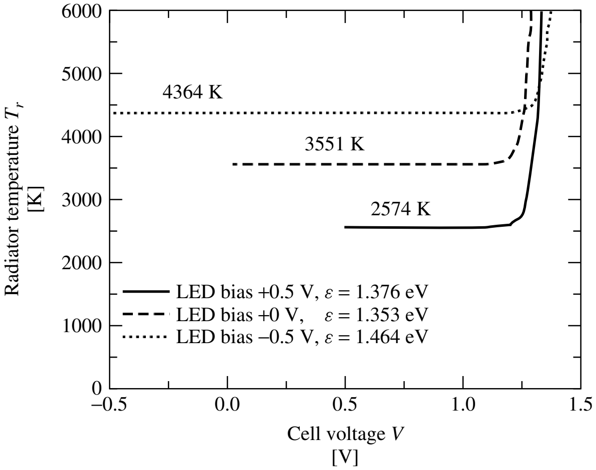

Figure 4.11 Hot cell temperature as a function of the cold cell voltage for several biasing voltages of the hot cell (LED) and for the energy that leads to maximum efficiency ($H_{rc}\Delta\varepsilon/H_{rs}\varepsilon = 10/\pi$). The energy ε has been optimised

see that higher efficiencies at lower temperatures can be obtained using the TPH concept under direct bias. This is not in contradiction to the fact that the limiting efficiency and the temperature for it is the same in both cases.

4.5.4 Higher-than-one Quantum Efficiency Solar Cells

One of the drawbacks that limit the efficiency of single-junction solar cells is the energy wasted from each photon that is absorbed because it is not converted into electrical power. Werner, Kolodinski, Brendel and Queisser [41, 42] have proposed a cell in which each photon may generate more than one electron–hole pair, thus leading to higher-than-one quantum efficiency solar cells. Without discussing which physical mechanisms may allow for this behaviour, let us examine its implications. Admitting that every photon may create $m(\varepsilon)$ electron–hole pairs, the current extracted from the device would be given by

$$I/q = \int_{\varepsilon_g}^{\infty} [m(\varepsilon)\dot{n}_s - m(\varepsilon)\dot{n}_r(T,\mu)]\,\mathrm{d}\varepsilon \tag{4.69}$$

In this equation, ε_g is the energy threshold for photon absorption and the factor m in the generation term is our initial assumption. The same term must appear in the recombination term to reach the detailed balance: if the sun temperature is brought to the ambient temperature, the current will be zero when $\mu = 0$, only if the factor m also appears in the recombination term. For the moment we are saying nothing about the chemical potential μ of the photons emitted.

The power delivered, $\dot{W}$, is given by

$$\dot{W} = \int_{\varepsilon_g}^{\infty} qV[m\dot{n}_s - m\dot{n}_r(T,\mu)]\,\mathrm{d}\varepsilon \tag{4.70}$$