We realise that the work extracted from the monochromatic cell is the same as that extracted from a Carnot engine fed with a heat rate from the hot reservoir $\Delta\dot{q} = (\dot{e}_s - \dot{e}_r)\Delta\varepsilon$. However, this similarity does not hold under a non-monochromatic illumination because, for a given voltage, the cell equivalent temperature would depend on the photon energy ε being unable to define a single equivalent temperature for the whole spectrum. Note that the equivalent cell temperatures corresponding to short-circuit and open-circuit conditions are T_a and T_s, respectively.

To calculate the efficiency, $\Delta\dot{W}$ in equation (4.25) must be divided by the appropriate denominator. We could divide by the black body incident energy $\sigma_{SB}T_s^4$, but this would be unfair because the unused energy that is reflected by the entry aperture could be deflected with an optical device and used in other solar converters. We can divide by $\dot{e}_s\Delta\varepsilon$, the rate of power received at the cell, thus obtaining the *monochromatic* efficiency, η_{mc}, given by

$$\eta_{mc} = \left.\frac{q(\dot{n}_s - \dot{n}_r)V}{\dot{e}_s}\right|_{max} = \left.\left(1 - \frac{\dot{e}_r}{\dot{e}_s}\right)\left(1 - \frac{T_a}{T_r}\right)\right|_{max} \tag{4.26}$$

that is represented in Figure 4.4 as a function of the energy ε.

Alternatively, we could have used the standard definition of efficiency used in thermodynamics [30, 31] to compute the efficiency of the monochromatic cell. In this context, we put in the denominator the energy really wasted in the conversion process, that is, $(\dot{e}_s - \dot{e}_r)\Delta\varepsilon$. Actually, the energy $\dot{e}_r\Delta\varepsilon$ is returned to the sun, perhaps for later use (slowing down, for example, the sun's energy loss process!). This leads to the *thermodynamic* efficiency:

$$\eta_{th} = \left(1 - \frac{T_a}{T_r}\right) \tag{4.27}$$

This efficiency is the same as the Carnot efficiency obtained by a reversible engine operating between an absorber at temperature T_r and the ambient temperature and suggests that an ideal solar cell may work reversibly, without entropy generation. Its maximum,

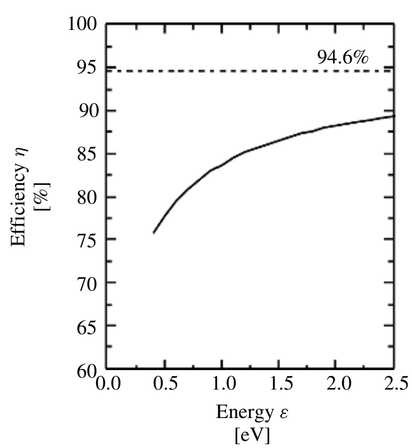

Figure 4.4 Monochromatic cell efficiency versus photon energy