As a mater of fact, this converter is a generalisation of the TPV converter. If the LED is in short circuit, the TPH converter is exactly the same as the TPV converter. The application of a voltage to the LED changes the converter properties.

Ideal LEDs are like solar cells. Thus, to describe the ideal TPH converter, we shall refer to the LED as the hot cell, as opposed to the electric power generator, which is the cold cell. When they are considered as ideal devices, the current–voltage characteristics of both, the LED and the solar cell, are the same. This causes the current passing by the cold cell to be faithfully replicated (with the sign changed) by the hot cell, owing to the reciprocal illumination of both devices, as expressed by the two following equations:

$$I_c/q = \dot{N}(T_r, qV_r, \varepsilon_g, \infty, H_{rc}) - \dot{N}(T_a, qV_c, \varepsilon_g, \infty, H_{rc}) \tag{4.58}$$

$$I_r/q = \dot{N}(T_a, qV_c, \varepsilon_g, \infty, H_{rc}) - \dot{N}(T_r, qV_r, \varepsilon_g, \infty, H_{rc}) \tag{4.59}$$

We shall use the subindex c for the cold solar cell current and voltage and r for the hot solar cell. The power generated by each cell is $\dot{W}_c = I_c V_c$ and $\dot{W}_r = I_r V_r$. In a normal operation, I_r is negative and the power generated by the hot cell is negative.

The application of the first law of thermodynamics to the cold and the hot cell, respectively, leads to

$$\dot{E}(T_r, qV_r, \varepsilon_g, \infty, H_{rc}) = \dot{E}(T_c, qV_c, \varepsilon_g, \infty, H_{rc}) + \dot{W}_c + \dot{Q}_c \tag{4.60}$$

$$\dot{Q}_r + \dot{E}(T_c, qV_c, \varepsilon_g, \infty, H_{rc}) = \dot{E}(T_r, qV_r, \varepsilon_g, \infty, H_{rc}) + \dot{W}_r \tag{4.61}$$

where $\dot{Q}_c$ is the heat rate delivered by the cold cell in the heat sink, while

$$\dot{Q}_r = \dot{E}(T_s, 0, 0, \infty, H_{rs}) - \dot{E}(T_r, 0, 0, \infty, H_{rs}) = \frac{H_{sr}\sigma_{\mathrm{SB}}}{\pi}(T_s^4 - T_r^4) \tag{4.62}$$

is the heat injected by the sun into the hot cell. The sum of equations (4.60) and (4.61) leads to

$$\dot{Q}_r - \dot{Q}_c = \dot{W}_r + \dot{W}_c = I_r(V_r - V_c) = I_c(V_c - V_r) = \dot{W} \tag{4.63}$$

where $\dot{W}$ is the algebraic sum of the powers produced by both cells (usually the hot cell will be absorbing, not producing, power).

In the case of monochromatic cell and LED operation, a proper filter of bandwidth $\Delta\varepsilon$ and centred at the energy ε is to be located somewhere in the optical system to allow for an interchange of photons only within the filter bandwidth. The preceding equations can be easily particularised in this case. An interesting relationship holding in this case, $\dot{e}\Delta\varepsilon = \varepsilon\dot{n}\Delta\varepsilon \equiv \dot{E}$, allows for a simple expression of the heat rate in both cells,

$$\dot{Q}_r = (V_r - \varepsilon/q)I_r \tag{4.64}$$

$$\dot{Q}_c = (\varepsilon/q - V_c)I_c \tag{4.65}$$