Calculating short circuit current density (J_{sc}) from external quantum efficiency (EQE)

External quantum efficiency (EQE) is defined as the ratio of number of charge carriers collected at the electrode to the number of photons incident on the solar cell. EQE is expressed as:

$$EQE(\lambda) = \frac{number\ of\ electrons\ collected}{number\ of\ photons\ incident} = \frac{N_e\,(\lambda)}{N_{ph}(\lambda)}$$

$$EQE(\lambda) = \frac{N_e/_{\Delta t.A}}{N_{ph}/_{\Delta t.A}} = \frac{electron\ flux}{photon\ flux}$$

Where, Δt is time duration and A is area

Volume current density (J_{sc}) = (electron flux) * (charge of electron)

$$J_{sc}(\lambda) = \frac{N_e\,q}{\Delta t.A}$$

$$EQE(\lambda) = \frac{\frac{N_e\,q}{\Delta t.A} * \frac{1}{q}}{\frac{N_{ph}}{\Delta t.A}} = \frac{\frac{J_{sc}\,(\lambda)}{q}}{\frac{N_{ph}}{\Delta t.A}}$$

$$\left(\frac{N_{ph}}{\Delta t.A}\right) \times h\nu = \frac{N_{ph}}{\Delta t.A} \times \frac{hc}{\lambda} = P_0(\lambda)$$

Where, $\frac{hc}{\lambda}$ is energy of photon at corresponding wavelength and $P_0(\lambda)$ is energy of photon having wavelength (λ) per unit area per unit time.

$$EQE(\lambda) = \frac{J_{sc}\,(\lambda)/_q}{\left(\frac{N_{ph}}{\Delta t.A} * \frac{hc}{\lambda}\right)\frac{\lambda}{hc}} = \frac{J_{sc}\,(\lambda)/_q}{P_0(\lambda)\frac{\lambda}{hc}}$$

$$J_{SC}(\lambda) = q\ EQE(\lambda)\frac{P_0}{hc/\lambda}$$

The AM1.5G spectra is available in the form of energy of photon per unit area per unit time per unit wavelength as shown in figure 1.

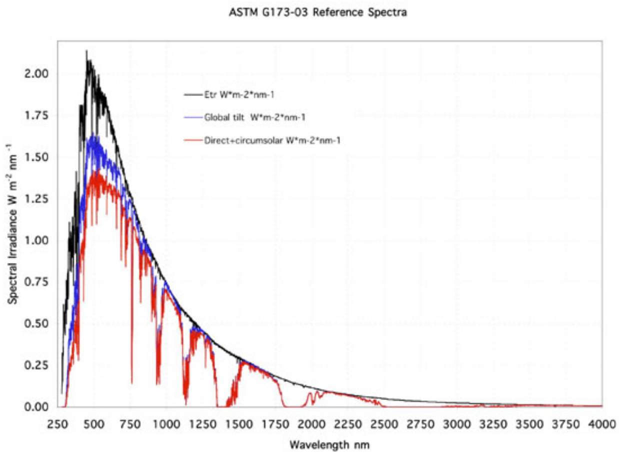

Figure 1 Reference air mass 1.5 spectra

Therefore if P_0 is replaced by AM1.5G data , J_{SC} should be written in the following form.

$$J_{SC}(\lambda) = qEQE(\lambda)\frac{P_0/\lambda}{hc/\lambda}\lambda$$

For a small range of wavelength, the expression would be

$$dJ_{SC}(\lambda) = qEQE(\lambda)\frac{P_0/\lambda}{hc/\lambda}d\lambda$$

By integrating the expression over a wavelength range λ_1 to λ_2, J_{sc} can be obtained.

$$J_{sc} = q\int_{\lambda 1}^{\lambda 2} EQE(\lambda)\frac{\frac{P_0(\lambda)}{\lambda}}{hc/_{\lambda}}\ d\lambda = q\int_{\lambda 1}^{\lambda 2} EQE(\lambda)\ \phi_{ph,\lambda}^{AM1.5G}\ d\lambda$$

Where, $\phi_{ph,\lambda}^{AM1.5G} = \frac{AM1.5G(\lambda)}{hc/_{\lambda}}$