Errata for SAM Photovoltaic Model Technical Reference

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This document lists errors with corrections for the SAM photovoltaic reference manual available from the link at the bottom of this page or from the Performance Model Documentation page on the SAM website.

Gilman, P.; (2015) “SAM Photovoltaic Model Technical Reference." TP-6A20-64102. Golden, CO: National Renewable Energy Laboratory.

Chapter 3: Irradiance and Weather Data

In **Table 2 Weather Data** and **Table 3 Sun Position Variable Definitions**, the time zone and longitude should be degrees East of GMT and 0° rather than West.

Also, the range of values for time zone is $-12 < tz < 12$, for longitude is $-180^\circ < lon < 180^\circ$, and for latitude is $0^\circ < lat < 90^\circ$.

Section 4.2: Sun Angles

In **Equation 4.18**, the final condition should be $a < -1$ instead of $a < 1$.

Correct:

$$a = \sin\delta \sin\left(\frac{\pi}{180} lat\right) + \cos\delta \cos\left(\frac{\pi}{180} lat\right) \cos HA$$

$$\alpha_0 = \begin{cases} \arcsin a & \text{if } -1 \le a \le 1 \\ \frac{\pi}{2} & \text{if } a > 1 \\ -\frac{\pi}{2} & \text{if } a < -1 \end{cases}$$

Incorrect:

$$a = \sin\delta \sin\left(\frac{\pi}{180} lat\right) + \cos\delta \cos\left(\frac{\pi}{180} lat\right) \cos HA$$

$$\alpha_0 = \begin{cases} \arcsin a & \text{if } -1 \le a \le 1 \\ \frac{\pi}{2} & \text{if } a > 1 \\ -\frac{\pi}{2} & \text{if } a < 1 \end{cases}$$

In **Equation 4.19** for the sun altitude angle corrected for refraction, the equation for refraction r for the case $\alpha_{0d} > -0.56$ is incorrect.

Correct:

$$\alpha_{0d} = \frac{180}{\pi}\alpha_0$$

$$r = \begin{cases} 3.51561\left(0.1594 + 0.0196\alpha_{0d} + 0.00002\alpha_{0d}^2\right)\left(1 + 0.505\alpha_{0d} + 0.0845\alpha_{0d}^2\right)^{-1} & \text{if } \alpha_{0d} > -0.56 \\ 0.56 & \text{if } \alpha_{0d} \le -0.56 \end{cases}$$

$$\alpha = \begin{cases} \frac{\pi}{2} & \text{if } \alpha_{0d} + r > 90 \\ \frac{\pi}{180}\left(\alpha_{0d} + r\right) & \text{if } \alpha_{0d} + r \le 90 \end{cases}$$

Incorrect:

$$\alpha_{0d} = \frac{180}{\pi}\alpha_0$$

$$r = \begin{cases} \alpha_{0d} + 3.51561\left(\frac{0.1594 + 0.0196\alpha_{0d} + 0.00002\alpha_{0d}^2}{1 + 0.505\alpha_{0d} + 0.0845\alpha_{0d}^2}\right) & \text{if } \alpha_{0d} > -0.56 \\ 0.56 & \text{if } \alpha_{0d} \le -0.56 \end{cases}$$

$$\alpha = \begin{cases} \frac{\pi}{2} & \text{if } \alpha_{0d} + r > 90 \\ \frac{\pi}{180}\left(\alpha_{0d} + r\right) & \text{if } \alpha_{0d} + r \le 90 \end{cases}$$

Section 4.3: Sunrise and Sunset Hours

In **Equation 4.23** for the equation of time in hours, the equation for a uses $\frac{\pi}{180}$ instead of $\frac{180}{\pi}$.

Correct:

$$a = \frac{1}{15}\left(mnlong - \frac{180}{\pi}ra\right)$$
$$EOT = \begin{cases} a & \text{if } -0.33 \leq a \leq 0.33 \\ a+24 & \text{if } a < -0.33 \\ a-24 & \text{if } a > 0.33 \end{cases}$$

Incorrect:

$$a = \frac{1}{15}\left(mnlong - \frac{\pi}{180}ra\right)$$
$$EOT = \begin{cases} a & \text{if } -0.33 \leq a \leq 0.33 \\ a+24 & \text{if } a < -0.33 \\ a-24 & \text{if } a > 0.33 \end{cases}$$

Equation 4.24 and **Equation 4.25** use the undefined variable λ for the longitude instead of lon.

Correct:

$$t_{sunrise} = 12 - \frac{1}{15}\frac{180}{\pi}HAR - \left(\frac{lon}{15} - tz\right) - EOT$$

$$t_{sunrise} = 12 + \frac{1}{15}\frac{180}{\pi}HAR - \left(\frac{lon}{15} - tz\right) - EOT$$

Incorrect:

$$t_{sunrise} = 12 - \frac{1}{15}\frac{180}{\pi}HAR - \left(\frac{\lambda}{15} - tz\right) - EOT$$

$$t_{sunrise} = 12 + \frac{1}{15}\frac{180}{\pi}HAR - \left(\frac{\lambda}{15} - tz\right) - EOT$$

Section 6.2.2 HDKR Model

In **Equation 6.11**, the equation for the isotropic component incorrectly uses the angle of incidence AOI instead of the subarray tilt angle β_s.

Correct:

$$cir = E_d A_i R_b$$
$$iso = E_d\,(1 - A_i)\,\frac{1 + \cos\,\beta_s}{2}$$
$$isohor = iso\,(1 + fs)$$

Incorrect:

$$cir = E_d A_i R_b$$
$$iso = E_d\,(1 - A_i)\,\frac{1 + \cos AOI}{2}$$
$$isohor = iso\,(1 + fs)$$

Section 6.2.3 Perez 1990 Model

Equation 6.14 for the a and b parameters in the Perez 1990 sky diffuse irradiance model uses the angle of incidence AOI instead of the sun zenith angle Z.

Correct:

$$a = \max(0, \cos AOI)$$
$$b = \max(\cos 85^\circ, \cos Z)$$

Incorrect:

$$a = \max(0, \cos AOI)$$
$$b = \max(\cos 85^\circ, \cos AOI)$$

Section 8.3 Sky Diffuse POA Irradiance Reduction

Parentheses are missing from **Equation 8.9** for the reduction in sky diffuse POA irradiance, which is part of the self-shading algorithm.

Correct:

$$G_{sky,\text{red}} = G_d - G_{dh}\left(1 - \cos^2\frac{\psi}{2}\right)\frac{N_{rows} - 1}{N_{rows}}$$

Incorrect:

$$G_{sky,\text{red}} = G_d - G_{dh}\ 1 - \cos^2\frac{\psi}{2}\ \frac{N_{rows} - 1}{N_{rows}}$$

Section 8.6: Beam Self-shading DC Loss Factor

The symbol for the submodule **fill factor** variable is inconsistent. It should be F_{fill} instead of FF_0.

Equation 8.23 uses m_d for the number of bypass diodes instead of d. Note that the number of bypass diodes is fixed at $d = 3$, as expained in Section 8.1.

Correct:

$$F_{dc1} = 1 - C_1 S^2 - C_2 S$$
$$F_{dc2} = \begin{cases} \dfrac{X - S\left(1 + 0.5 d V_{mp}^{-1}\right)}{X} & \text{if } X > 0 \\ 0 & \text{if } X = 0 \end{cases}$$
$$F_{dc3} = C_3 (S - 1) + R_{dt}$$

Incorrect:

$$F_{dc1} = 1 - C_1 S^2 - C_2 S$$
$$F_{dc2} = \begin{cases} \dfrac{X - S\left(1 + 0.5 m_d V_{mp}^{-1}\right)}{X} & \text{if } X > 0 \\ 0 & \text{if } X = 0 \end{cases}$$
$$F_{dc3} = C_3 (S - 1) + R_{dt}$$

Section 9.4: Sandia Module Model

Equation 9.5 for effective irradiance is missing brackets to show the correct order of multiplication and addition.

Correct:

$$E_e = \frac{I_{sc}}{I_{sc,ref}\left[1+\alpha_{sc,ref}(T_c-25)\right]}$$

Incorrect:

$$E_e = \frac{I_{sc}}{I_{sc,ref}\ 1+\alpha_{sc,ref}(T_c-25)}$$

Equation 9.6 is also missing brackets:

Correct:

$$I_{mp} = I_{mp,ref}(C_0E_e + C_1E_e^2)\left[1+\alpha_{sc,ref}(T_c-25)\right]$$

Incorrect:

$$I_{mp} = I_{mp,ref}(C_0E_e + C_1E_e^2)\ 1+\alpha_{sc,ref}(T_c-25)$$

The equation for **open circuit voltage** is missing. It should be between Equations 9.7 and 9.8:

$$V_{oc} = V_{oc,ref} + s\ \Delta T_c \ln(E_e) + \beta_{oc}(T_c-25)$$

Equation 9.8 for voltage at maximum power uses log instead of ln. The logarithms should be natural logarithms.

Correct:

$$V_{mp} = V_{mp,ref} + C_2\ s\ \Delta T_c\ \ln(E_e) + C_3\ s\ \left[\Delta T_c \ln(E_e)\right]^2 + \beta_{mp}(T_c-25)$$

Incorrect:

$$V_{mp} = V_{mp,ref} + C_2\ s\ \Delta T_c\ \log(E_e) + C_3\ s\ \left[\Delta T_c \log(E_e)\right]^2 + \beta_{mp}(T_c-25)$$

Section 9.7: NOCT Cell Temperature Model

Equation 9.35 shows incorrect NOCT temperature adjustment for building integrated, greater than 3.5 in, or ground/rack mounted option.

Correct:

$$T_{noct,adj} = \begin{cases} T_{noct} & \text{building integrated, greater than 3.5 in, or ground/rack mounted} \\ T_{noct}+2 & \text{2.5 to 3.5 in} \\ T_{noct}+6 & \text{1.5 to 2.5 in} \\ T_{noct}+11 & \text{0.5 to 1.5 in} \\ T_{noct}+18 & \text{less than 0.5 in} \end{cases}$$

Incorrect:

$$T_{noct,adj} = \begin{cases} T_{noct}+2 & \text{building integrated, greater than 3.5 in, or ground/rack mounted} \\ T_{noct}+2 & \text{2.5 to 3.5 in} \\ T_{noct}+6 & \text{1.5 to 2.5 in} \\ T_{noct}+11 & \text{0.5 to 1.5 in} \\ T_{noct}+18 & \text{less than 0.5 in} \end{cases}$$

Equation 9.36 is missing brackets to show correct order of multiplication.

Correct:

$$T_c = T_a + \frac{G}{800}\left(T_{noct,adj} - 20\right)\left(1 - \frac{\eta_{ref}}{\tau\alpha}\right)\frac{9.5}{5.7 + 3.8v_{w,adj}}$$

Incorrect:

$$T_c = T_a + \frac{G}{800}T_{noct,adj} - 20\ 1 - \frac{\eta_{ref}}{\tau\alpha}\frac{9.5}{5.7 + 3.8v_{w,adj}}$$

Section 11.2: Sandia Inverter Submodel

Equation 11.3 for Sandia inverter model parameters is missing closing parentheses.

Correct:

$$\begin{aligned} A &= P_{dc,0}\left[1 + C_1(V_{dc} - V_{dc,0})\right] \\ B &= P_{s,0}\left[1 + C_2(V_{dc} - V_{dc,0})\right] \\ C &= C_0\left[1 + C_3(V_{dc} - V_{dc,0})\right] \end{aligned}$$

Incorrect:

$$\begin{aligned} A &= P_{dc,0}\left[1 + C_1(V_{dc} - V_{dc,0}\right] \\ B &= P_{s,0}\left[1 + C_2(V_{dc} - V_{dc,0}\right] \\ C &= C_0\left[1 + C_3(V_{dc} - V_{dc,0}\right] \end{aligned}$$