Row-to-row shade losses due to **sloping terrain** can be calculated using simple trigonometry for **First Solar modules on trackers** because there's no electric mismatch, irradiance losses are linearly proportional with shade, and trackers typically do not backtrack.

- First Solar (FS) modules have cells that extend from top to bottom of the module and are connected in series from left to right. Therefore, **row-to-row (r2r) shade affects all cells uniformly** and reduces output linearly proportional to the fraction of shade. Figure 1 shows a FS Series 6 module with cells in series from side to side.
- Therefore, **FS tracks the sun instead of backtracking**, even with r2r shade, to increase incident plane of array (POA) irradiance and take advantage of linear shade loss. Silicon modules must backtrack because r2r shade is not uniform across all cells causing non-linear electrical losses that are much greater than the shade loss.
- After trackers pass their rotation limits, the projected solar zenith will no longer be perpendicular to the modules. We can also **generalize for trackers on sloping terrain**. Figure 2 shows the generic case for trackers at any position (β) on sloping terrain (θ_g) with projected solar zenith (θ). Use trigonometry to determine the shadow on the ground (z) and the shade on the module (w) from the pitch (P), the module length (L), the tracker rotation (β), and the projected solar zenith (θ) as shown in Equation 1. Form similar triangles to derive the shade loss (w/L) as shown in Equation 2. Finally, in Equation 3, there's no shade loss when the shadow is less than the pitch projected on the ground.

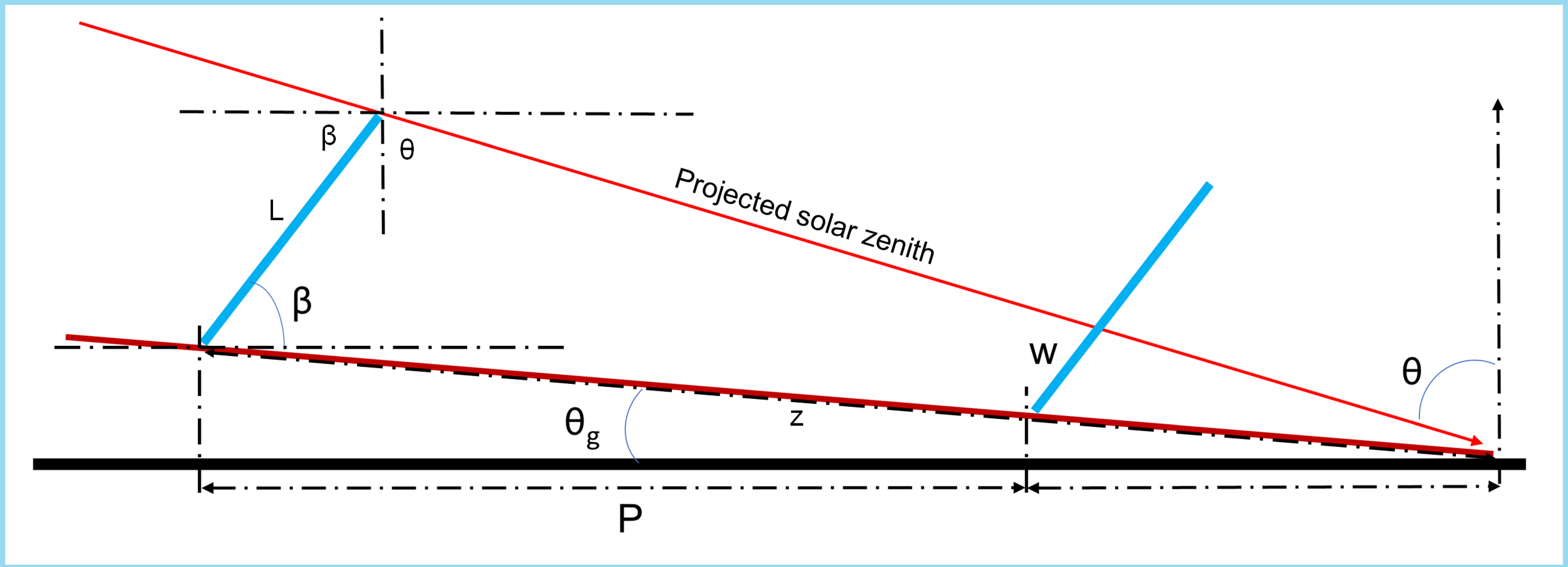

Figure 2: shows the generic case for trackers at any position on sloping terrain.

Figure 1: FS Series 6 module has cells extending from bottom to top, connected in series from left to right.

Equation 1: Calculate shadow (z) on the ground from projected solar zenith (θ), tracker position (β), ground slope (θ_g), and module length (L).

$$\frac{z}{\sin(\pi/2 + \theta - \beta)} = \frac{L}{\sin\left(\pi/2 - \theta - \theta_g\right)}$$

Equation 2: **The shade loss is the shade fraction!**

$$\frac{w}{L} = 1 - \frac{P}{z \cos \theta_g}$$

Equation 3: the shade loss is zero when there's no r2r shade, $z < P / \cos \theta_g$.

Questions? Comments? Scan the QR code below to email me and let's talk!

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