Orientation of Solar Panels

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1. Azimuth

Azimuth refers to the angle at which solar panels are oriented, measured clockwise from true north. In the southern hemisphere, the sun is positioned in the northern sky, so solar panels should be oriented to face north. Conversely, in the northern hemisphere, the sun is in the southern sky, and panels should be oriented to face south for optimal sunlight exposure.

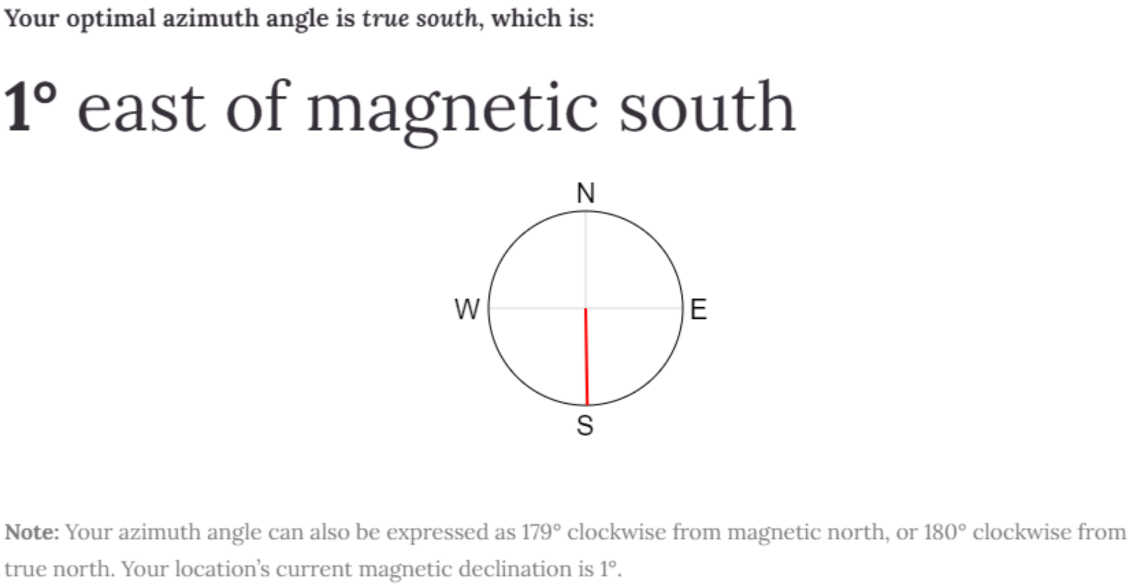

Figure 1: Azimuth angle.

2. Row Spacing

One of the most important factors to consider when designing the layout of solar panels is the row spacing. If the panels are too close together, they will cause self-shading, reducing energy production. However, if the distance between rows is too large, unnecessary land area will be used. The goal is to optimize the spacing by considering the worst-case scenario, which depends on the location's altitude and hemisphere, ensuring efficiency without wasting space.

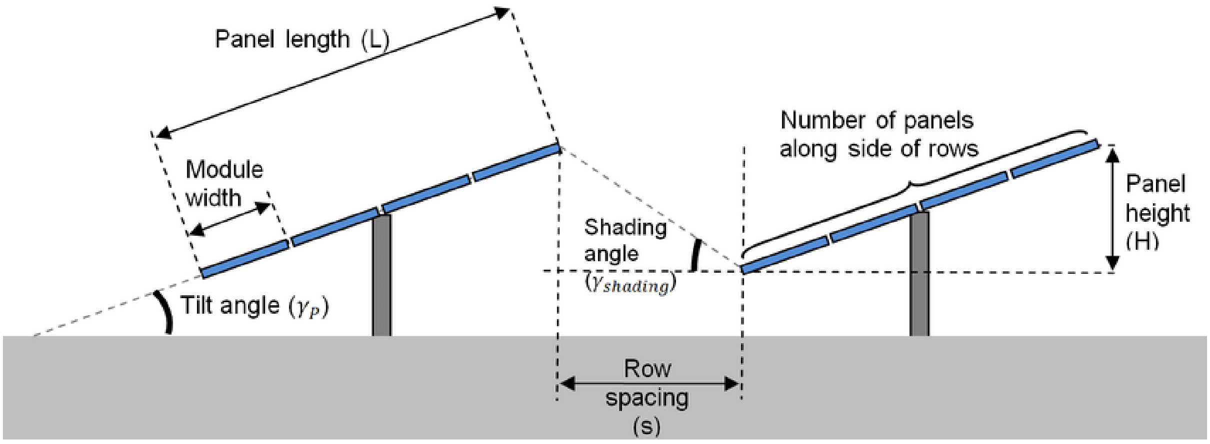

Figure 2: Row Spacing representation.

Example 1:

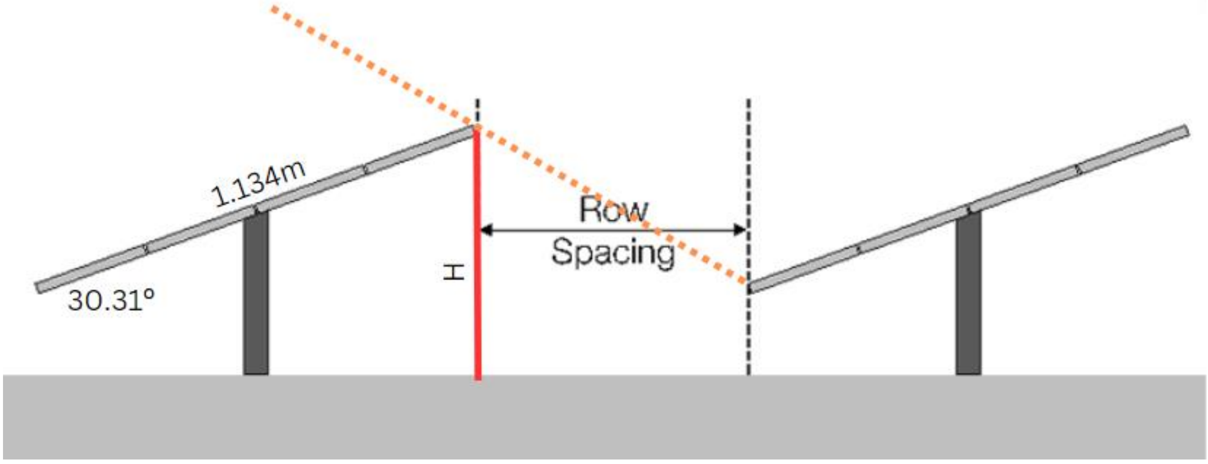

Figure 3: Example one representation.

Based on the latitude of 34.85 degrees and longitude of 118 degrees from an existing solar farm in the U.S.A and considering the dimensions of the solar panel to be 1919x1134x35mm, the optimal tilt angle for the solar panels can be determined by using the following equation.

$$Tilt\ Angle = 35 * 0.87 \ \approx 30.31$$

Equation 1: Tilt angle calculation.

Your optimal year-round tilt angle:

29.2° from horizontal

Figure 4: Actual Tilt angle in California.

With the tilt angle obtained, it's important to calculate the height that the solar panel reaches at an angle of 30.31 degrees. This height will help determine the optimal spacing between solar panels to avoid shading and maximize efficiency.

$$H = \frac{\sin 30.31°}{1.134m} \approx 0.57m$$

Equation 2: Calculation of the height.

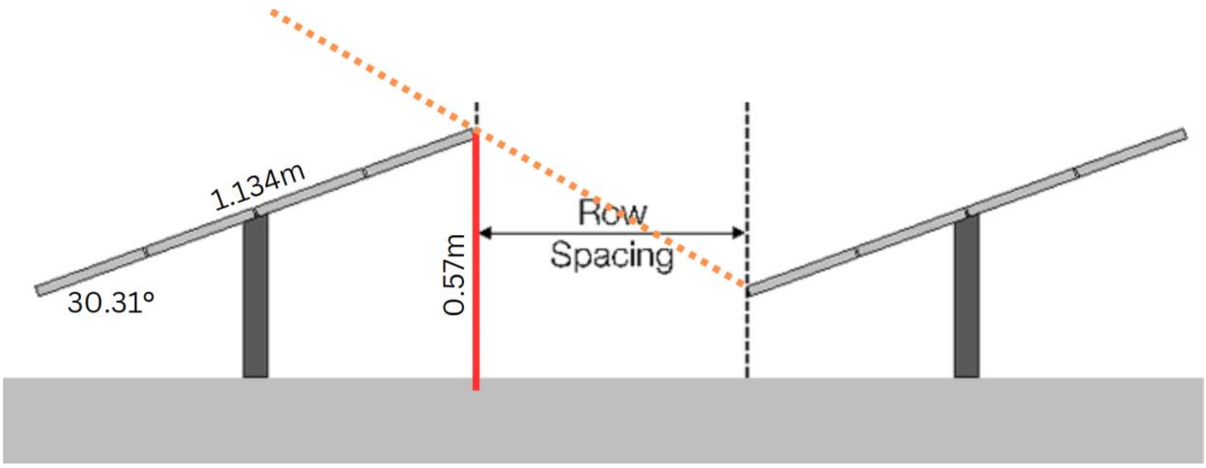

Figure 5: Representation of the row spacing with the height.

With the height found, the next step is to determine the sun's angle during the worst-case scenario, which occurs around December 21st (in the northern hemisphere) or June 21st (in the southern hemisphere), marking the winter solstice. This angle will help assess the potential shading and spacing between solar panel rows during this time.

$$Elevetion\ Angle = 90 - Altitude - 23.5$$

$$Elevetion\ Angle = 90 - 34.85 - 23.5 = 31.65°$$

Equation 3: Calculation for the Elevation angle.

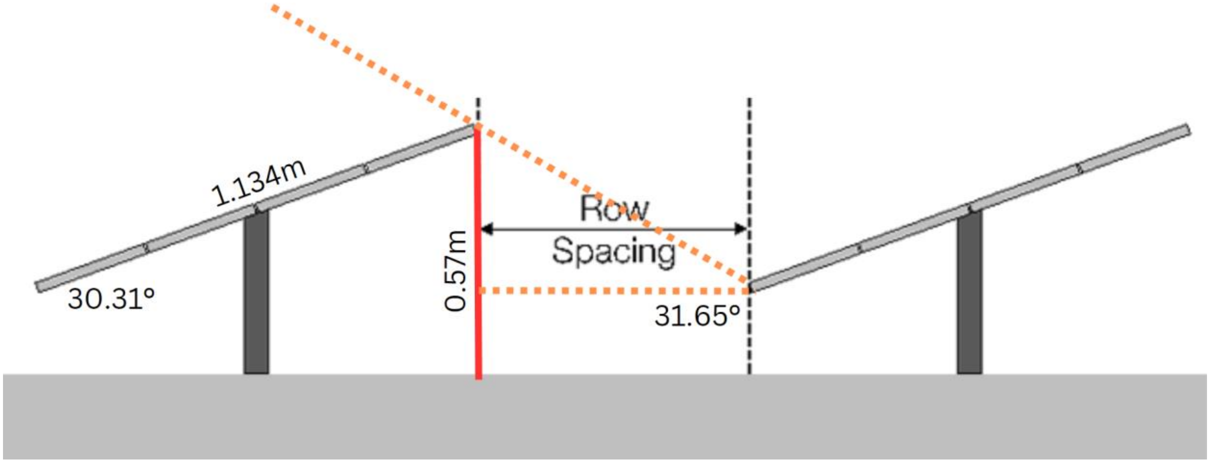

Figure 6: Representation of the raw spacing with the elevation angle.

With the elevation angle determined, the next step is to calculate the distance between the solar panels to prevent shading.

$$Distance = \frac{0.57}{\tan 31.65} = 0.925m$$

Equation 4: Calculation for the distance.

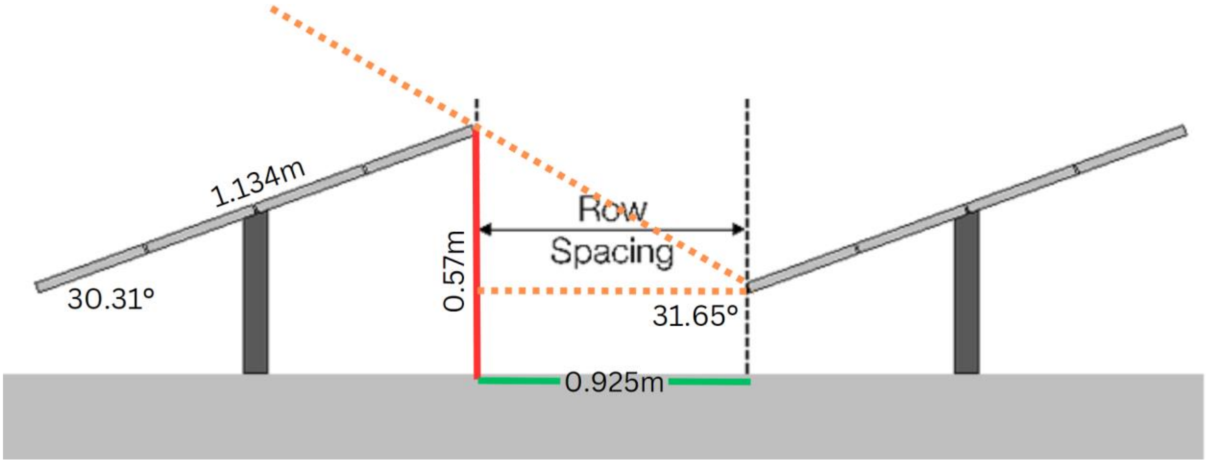

Figure 7: Representation of the row spacing with its distance.

The value obtained was of 0.925m or 1m, to obtain the total distance, it's only required to obtain the distance that forms the inclination of the panel, obtaining a value of 1.904m or 2m.

$$Distance = 1.134 * \cos 30.31° = 0.98m$$

$$Total\ Distance = 0.98\ +\ 0.925 = 1.904m$$

Equation 5: Calculation for the total distance.

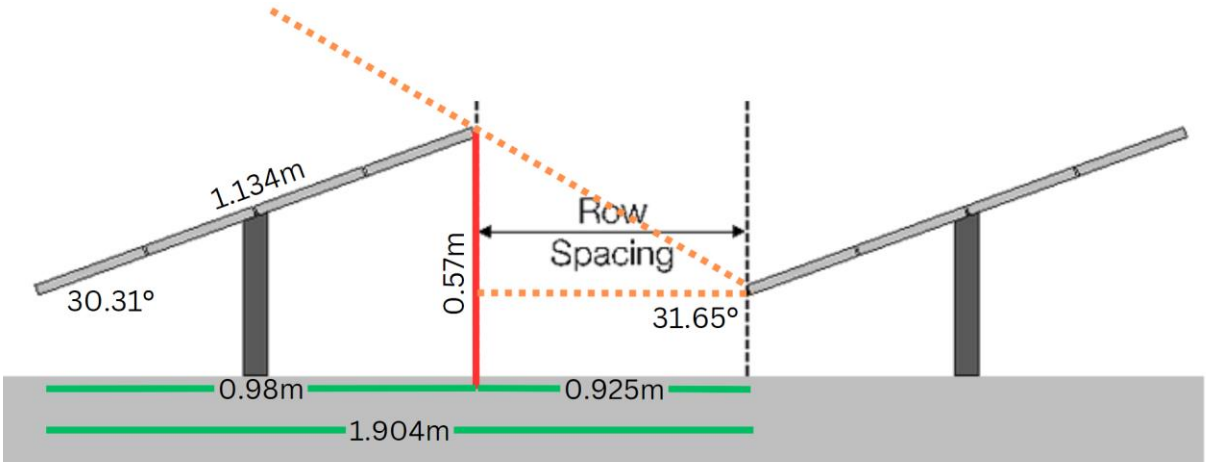

Figure 8: Final representation of the row spacing with all its values.

Example 2:

The previous exercise was done assuming a flat surface, but solar panels can also be installed on sloped terrain. In this case, the calculation process remains the same, but the inclination of the terrain must also be factored in. The row spacing should account for both the tilt of the panels and the slope of the surface to ensure proper alignment, avoiding self-shading and optimizing land use based on the combined angles.

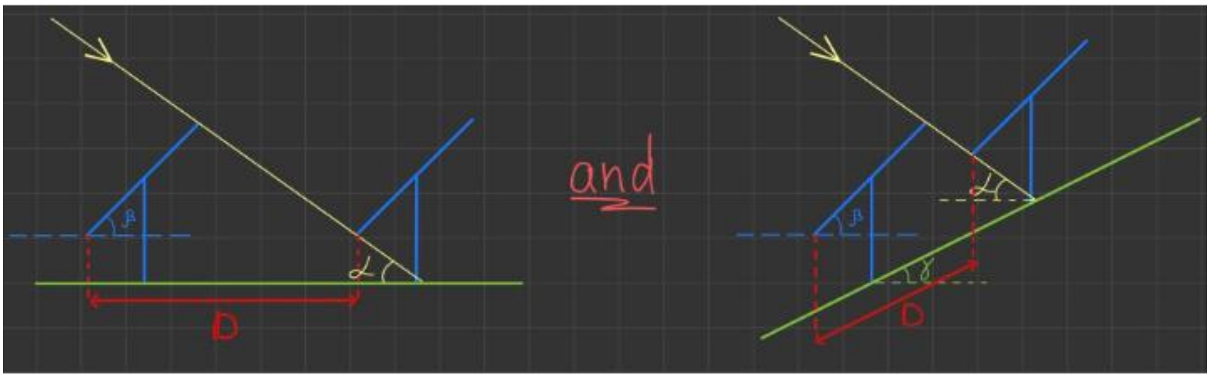

Figure 9: Representation of a flat surface and inclination surface configuration.

Using the previous example, it's possible to apply a formula to calculate the total distance between solar panels, taking into account both the tilt of the panels and the inclination of the terrain.

$$D = \frac{w * sin\left(180° - (\alpha - \gamma) - (\beta - \gamma)\right)}{\sin(\alpha + \gamma)}$$

$$D = \frac{1.134 * sin\left(180° - (31.65 - 0) - (30.31 - 0)\right)}{\sin(31.65 + 0)} = 1.907m$$

Equation 6: Total distance formula.