



Engineering & Design Considerations

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Agrivoltaic Array Types

Fixed-Tilt



<https://www.powerhouse-llc.com/project-1>

- Simple
- Relatively poor light uniformity

Single-Axis Tracking



<https://cleantechnica.com/2019/01/15/nextracker-rolls-bifacial-solar-dice-for-750-megawatts/>

- Good light uniformity
- Good electrical production

Vertical Bifacial



<https://www.next2sun.de/>

- Good light uniformity
- Easy vehicle access between rows

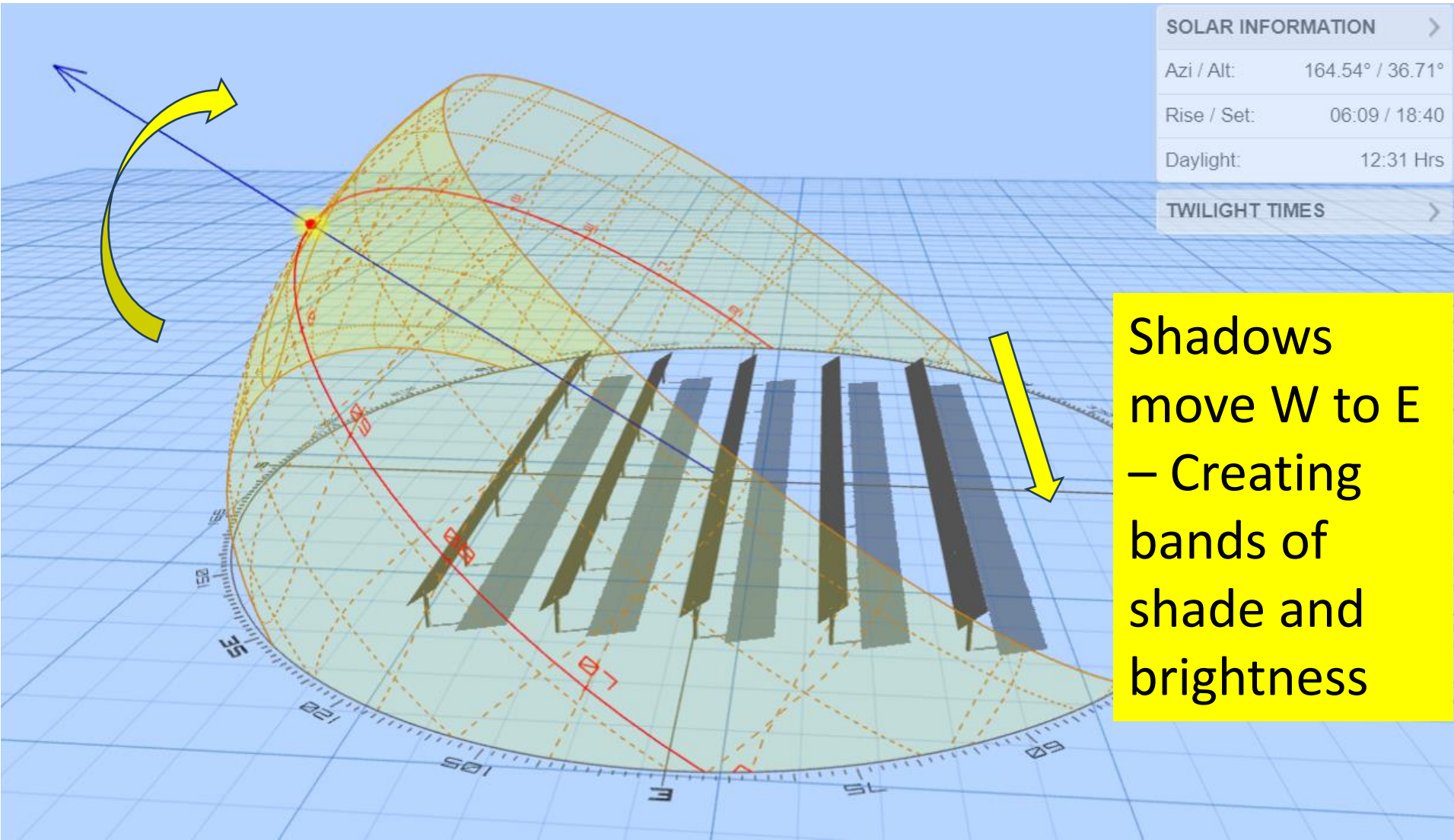
Fixed Tilt Arrays

- Simplest array type to install
- No moving parts
- Rows face south, run east to west
- Bad light uniformity on ground

<http://www.beltlineenergy.com/>



Fixed Tilt Arrays

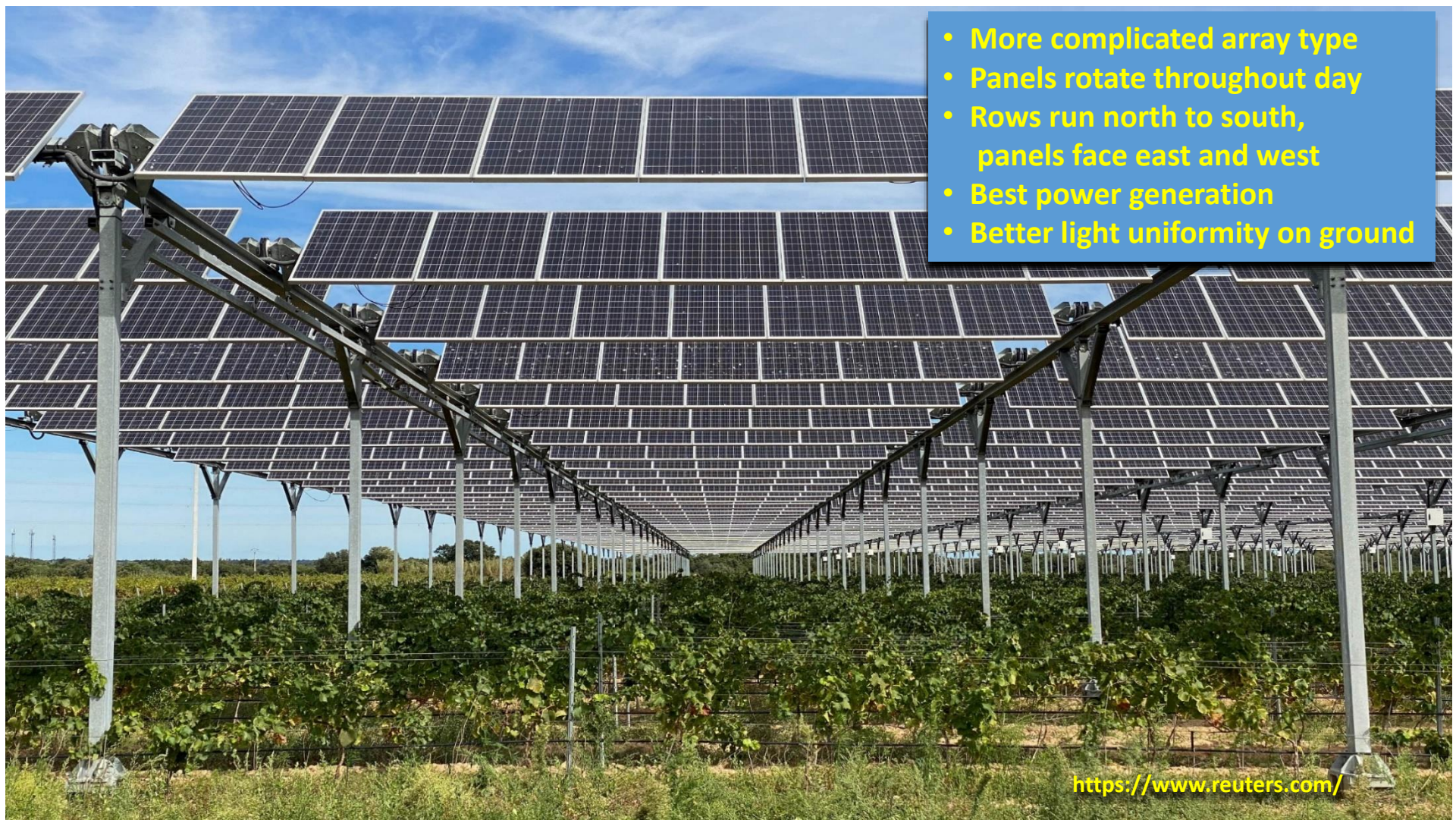


Sunpath shadow pattern created with:
<http://andrewmarsh.com/apps/staging/sunpath3d.html>

Single-Axis Tracking Arrays

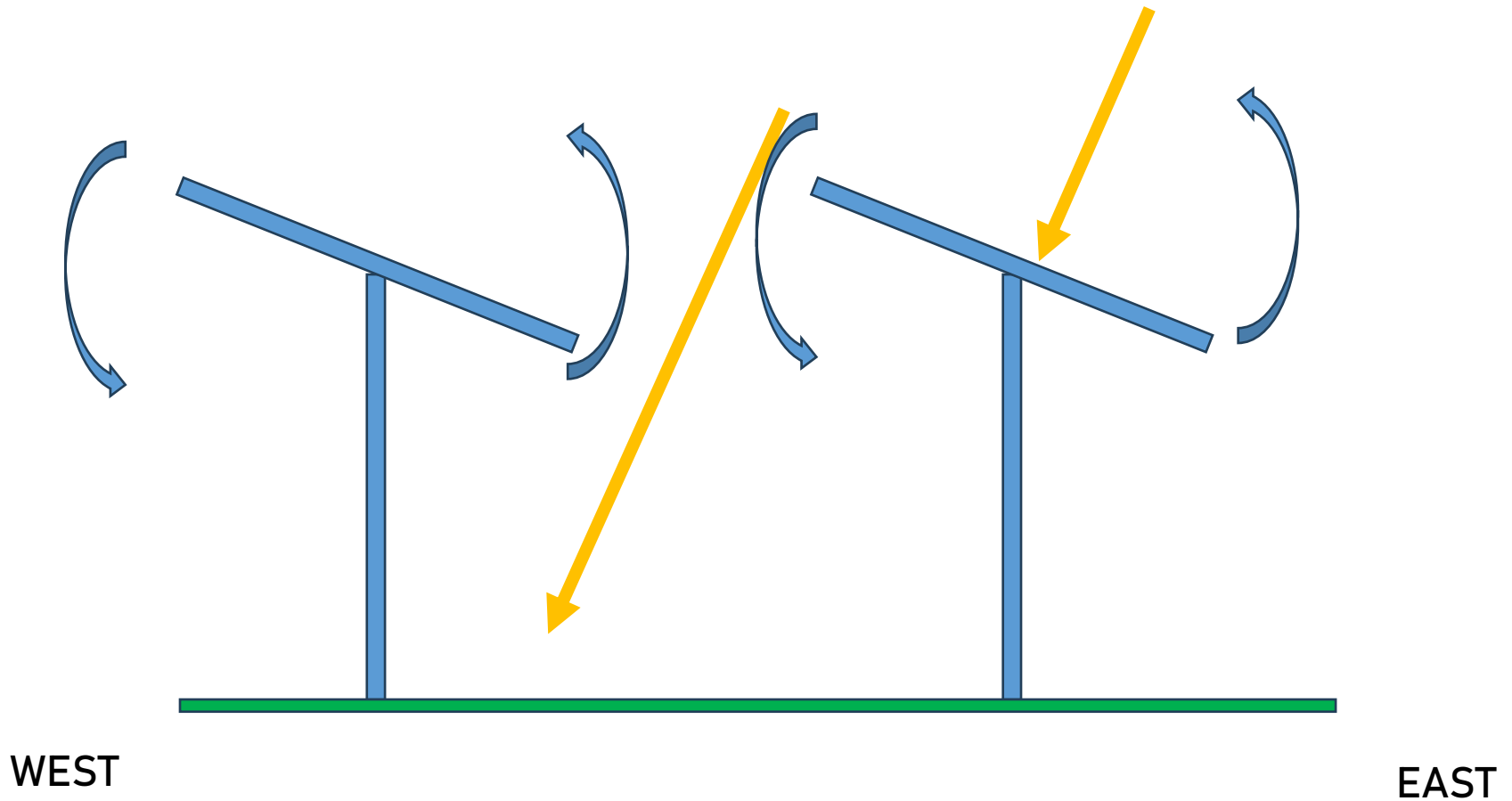
- More complicated array type
- Panels rotate throughout day
- Rows run north to south, panels face east and west
- Best power generation
- Better light uniformity on ground

<https://www.reuters.com/>



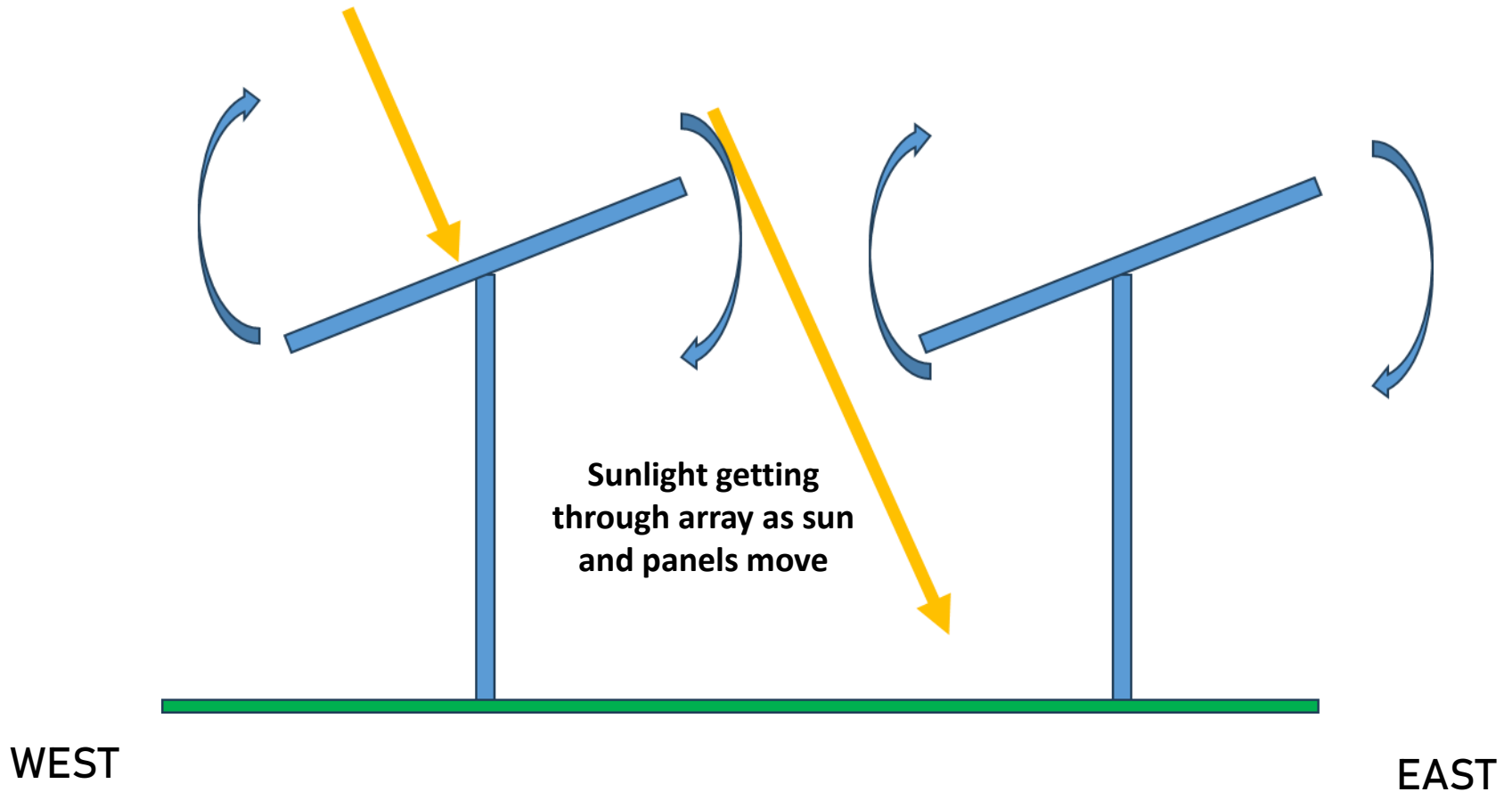
Single-Axis Tracking Arrays

Always points to sun when possible



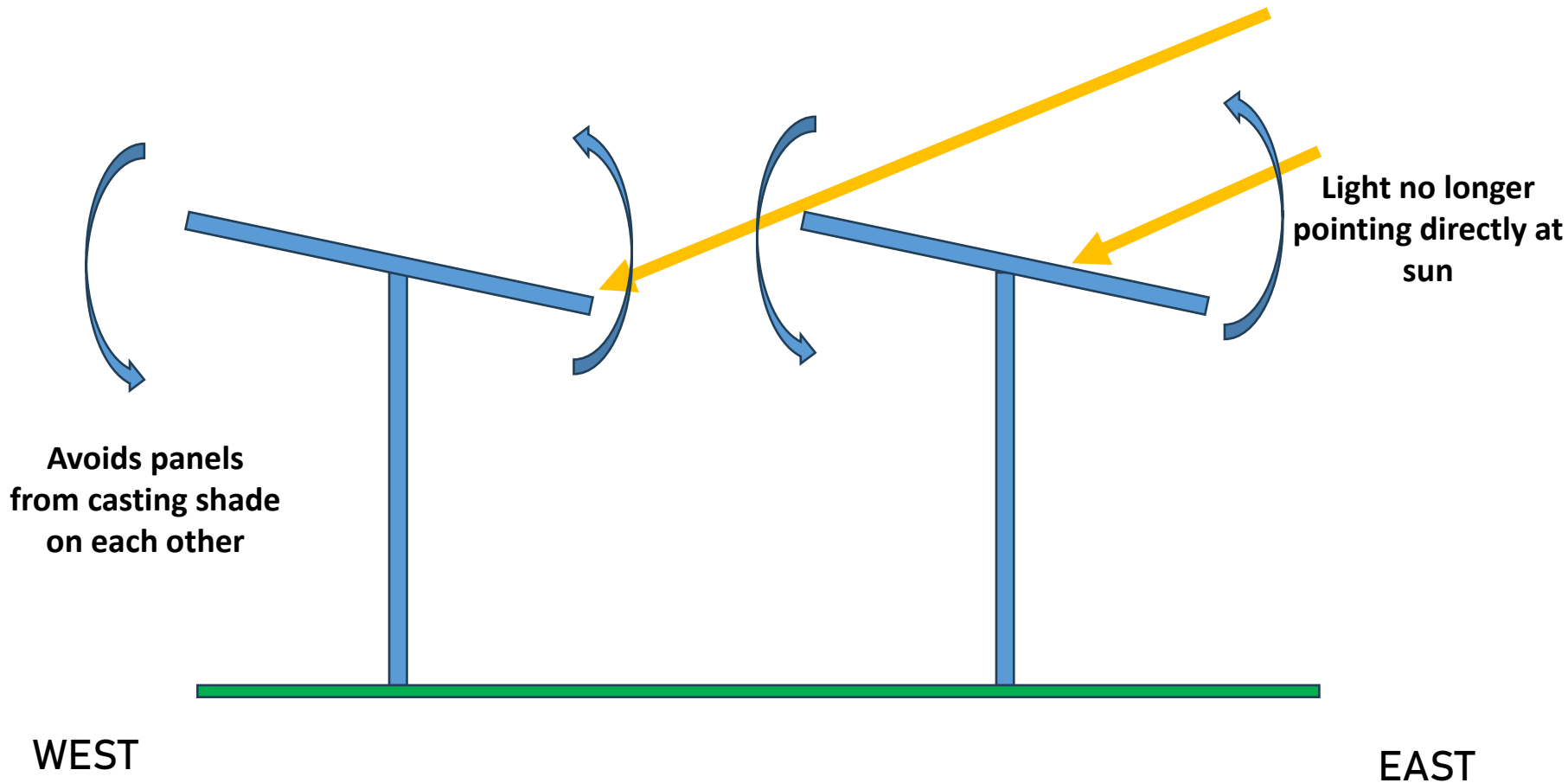
Single-Axis Tracking Arrays

Always points to sun when possible

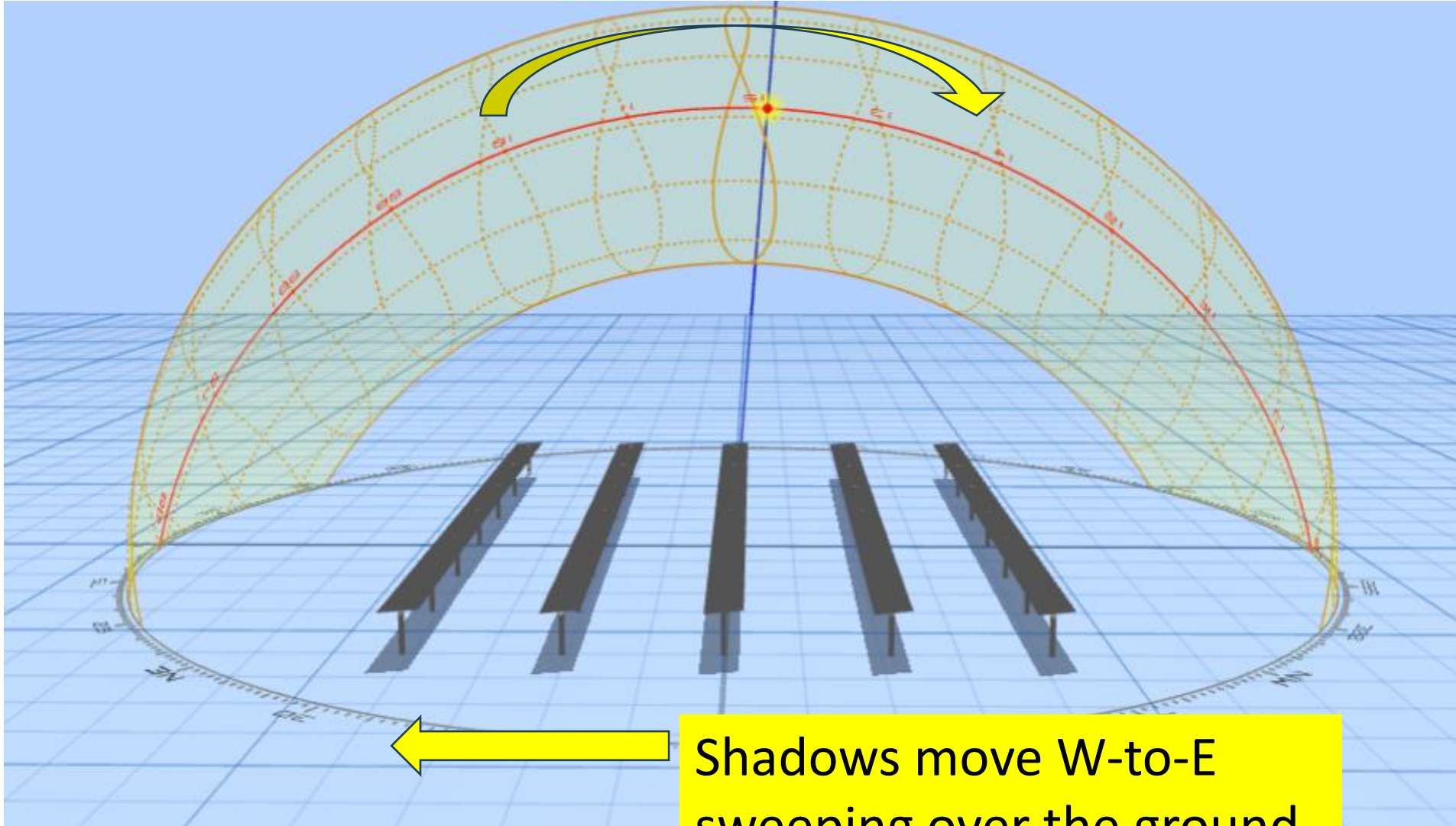


Single-Axis Tracking Arrays

“Backtracking” for early AM and late PM



Single-Axis Tracking Arrays



Shadows move W-to-E
sweeping over the ground
through the day

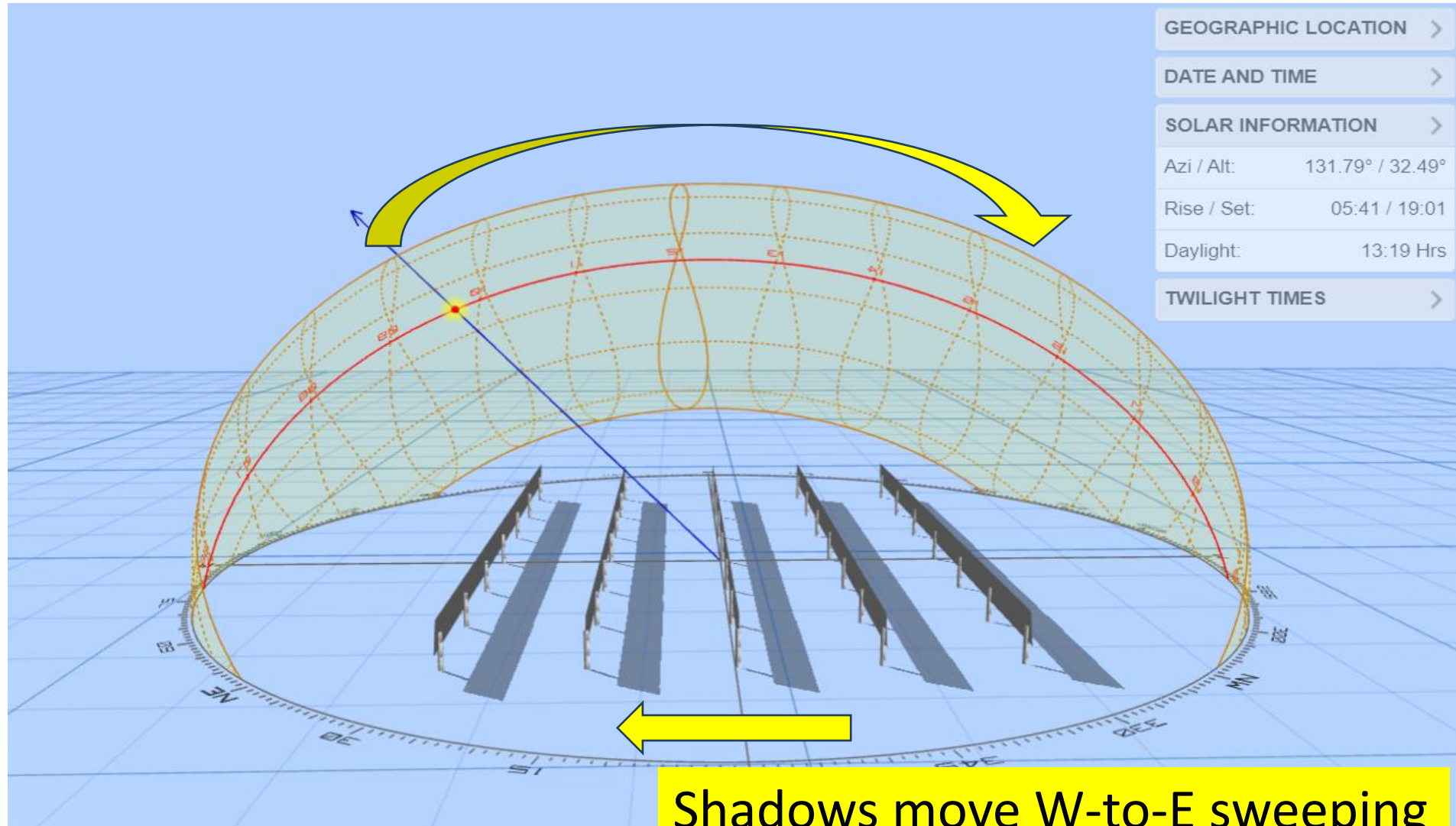
Sunpath shadow pattern created with:
<http://andrewmarsh.com/apps/staging/sunpath3d.html>

Vertical Bifacial Arrays

- Newer array type
- No moving parts
- No clearance issues for tall machinery
- Rows run north to south, panels face east and west
- Better light uniformity on ground



Vertical Bifacial Arrays



Shadows move W-to-E sweeping over the ground through the day

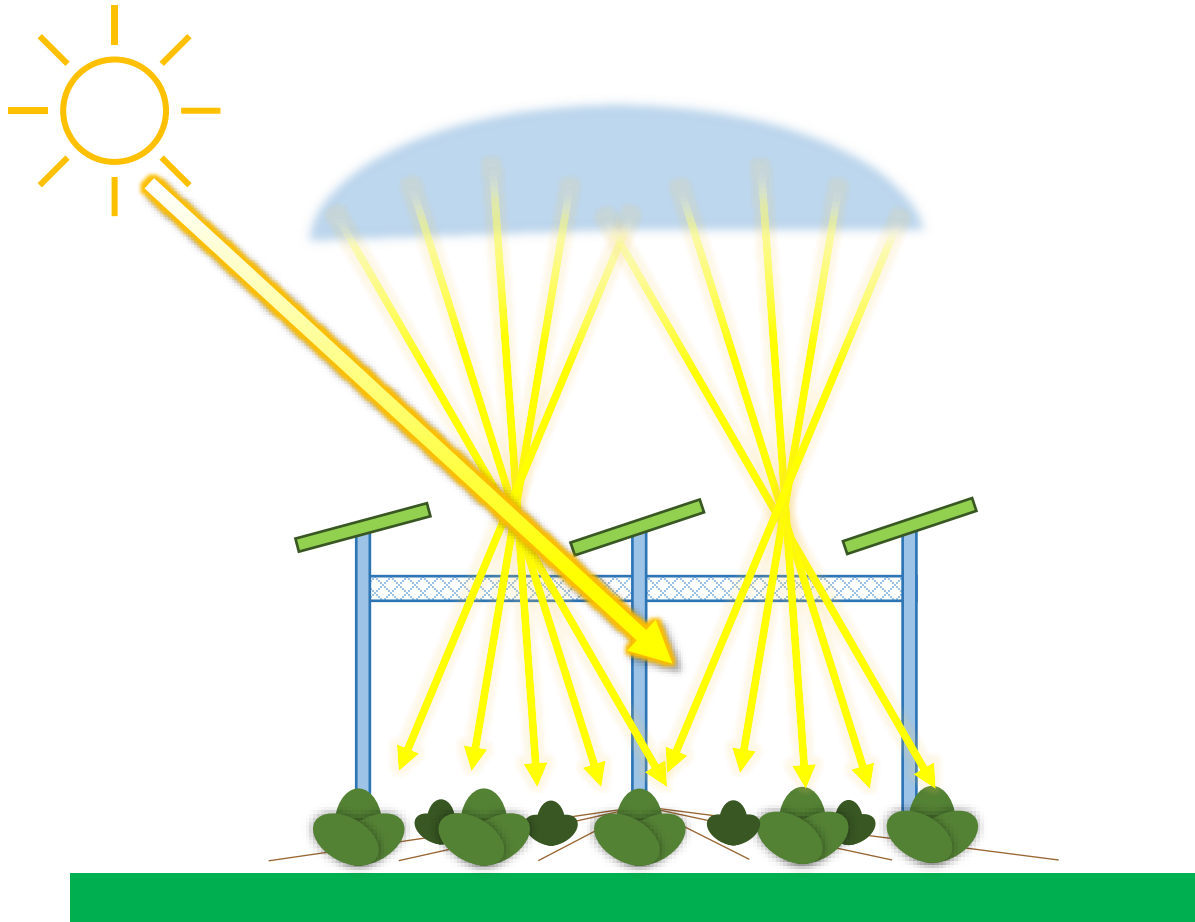
Sunpath shadow pattern created with:
<http://andrewmarsh.com/apps/staging/sunpath3d.html>



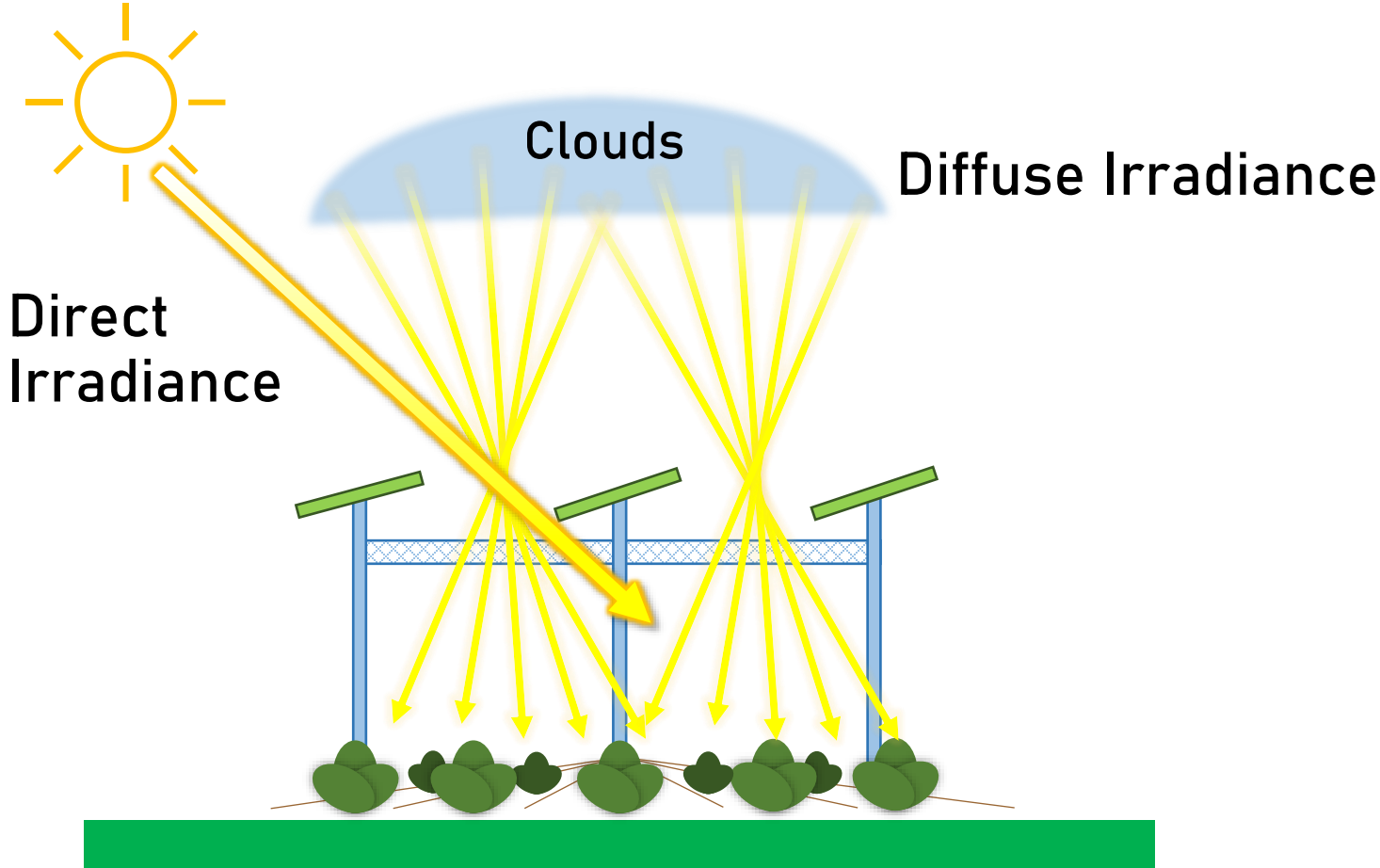
Shading Analysis Considerations

Dunbar P. Birnie III and Ross Rucker

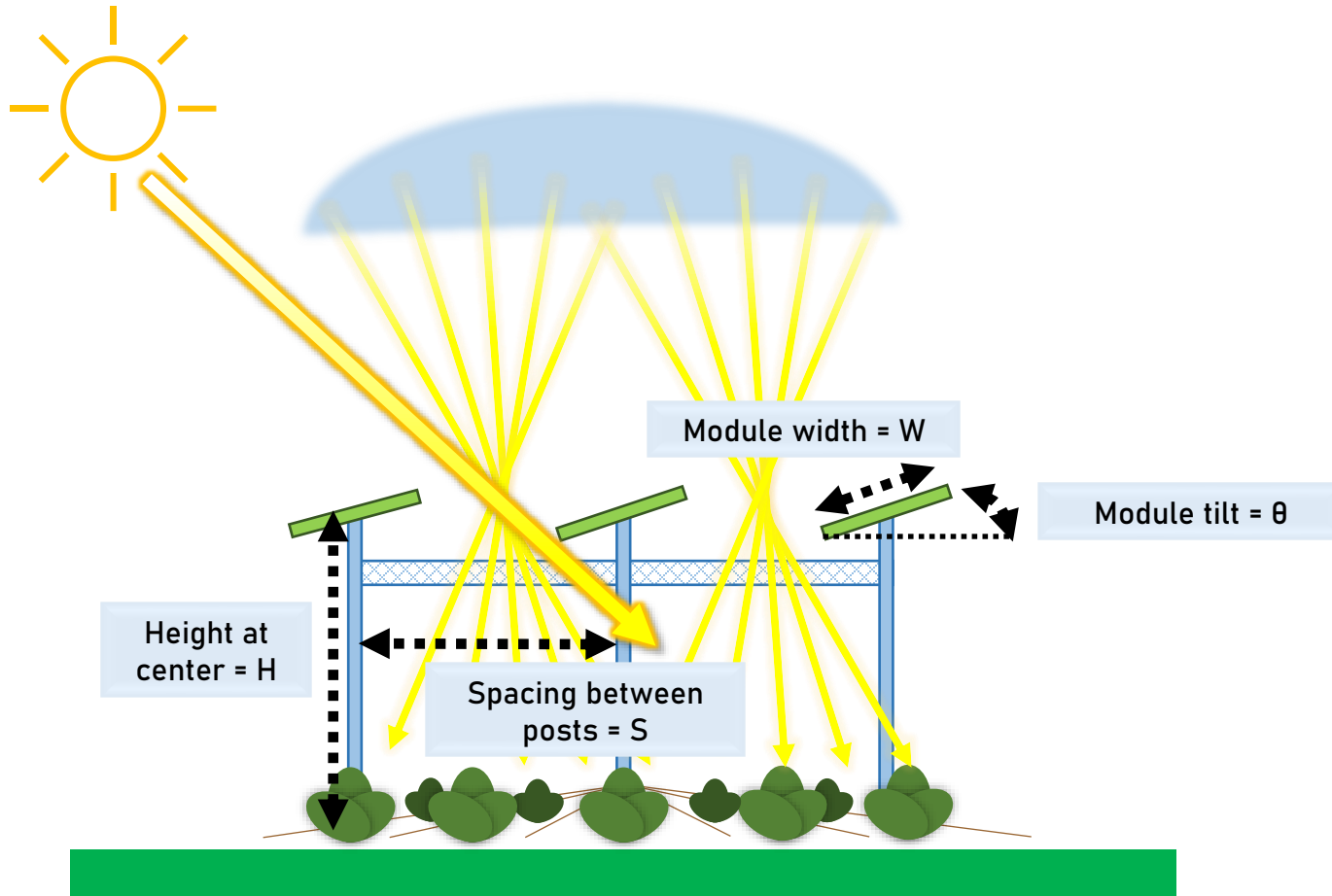
Agrivoltaic Design Considerations



Agrivoltaic Design Considerations



Agrivoltaic Design Considerations



“Ground Coverage Ratio”
(GCR) = W/S

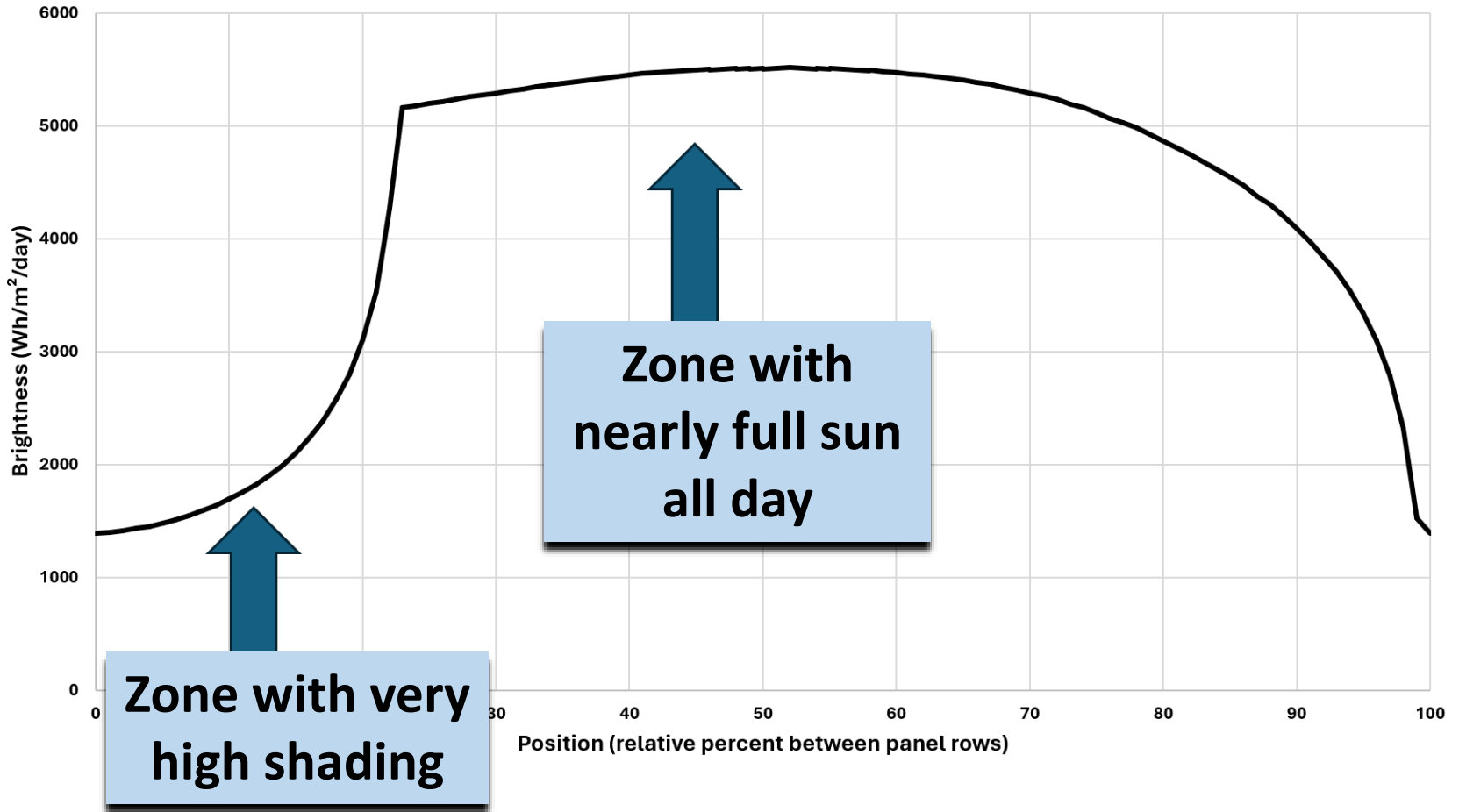
Fixed Tilt Arrays



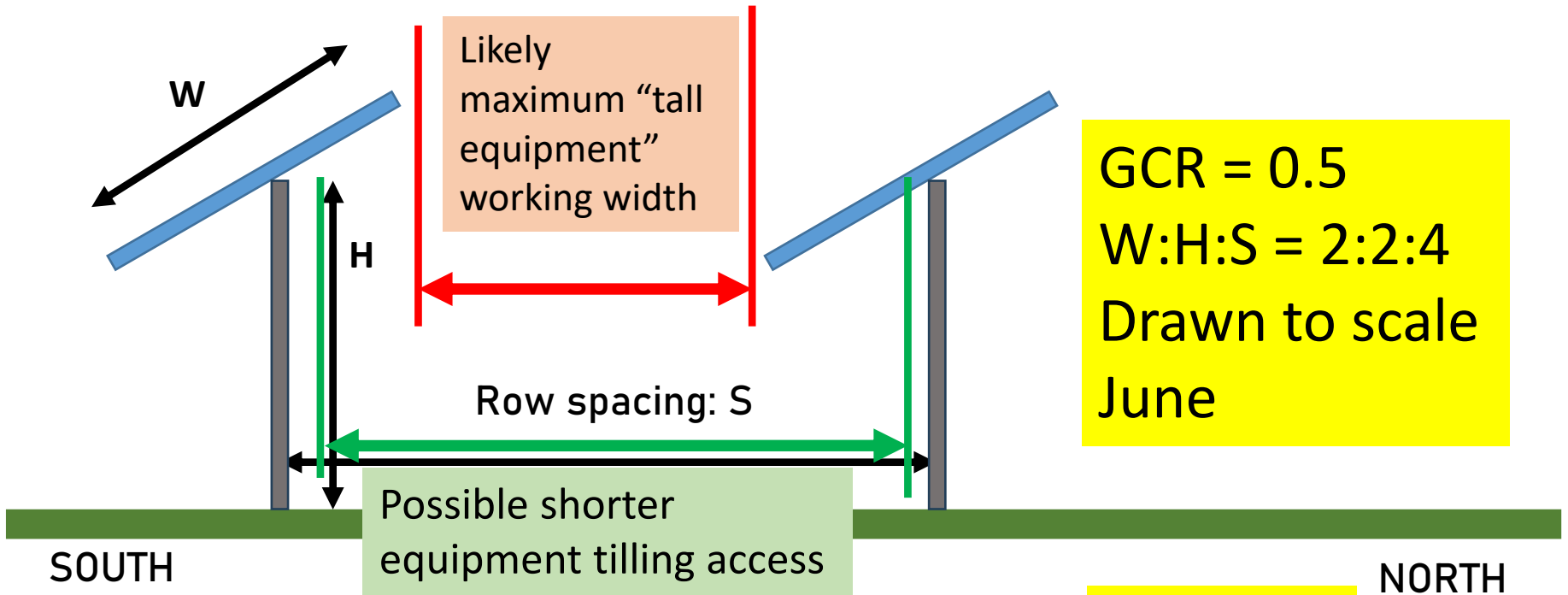
<http://www.beltlineenergy.com/>

Fixed Tilt Arrays

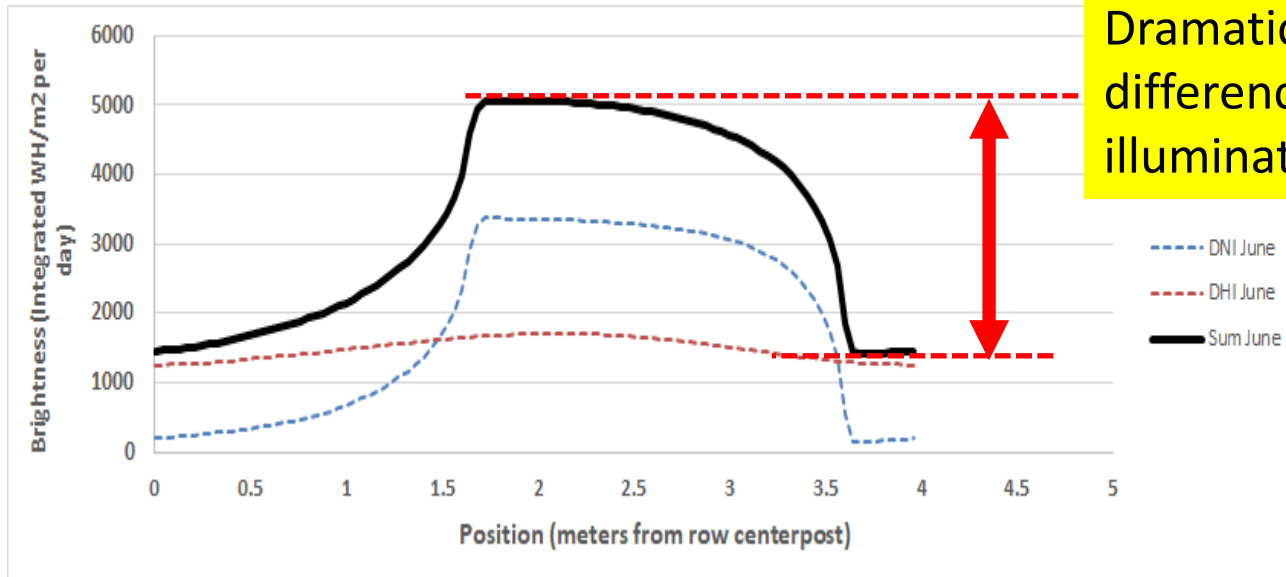
Shading Pattern for New Brunswick in June



Fixed Tilt Arrays



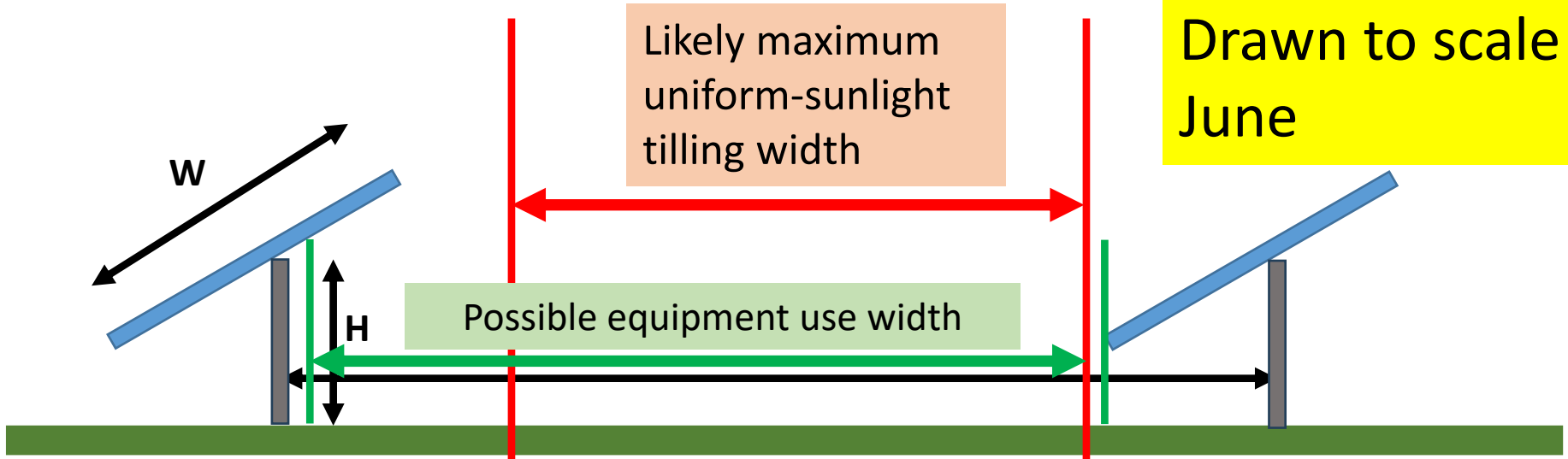
GCR = 0.5
 W:H:S = 2:2:4
 Drawn to scale
 June



Dramatic difference in illumination

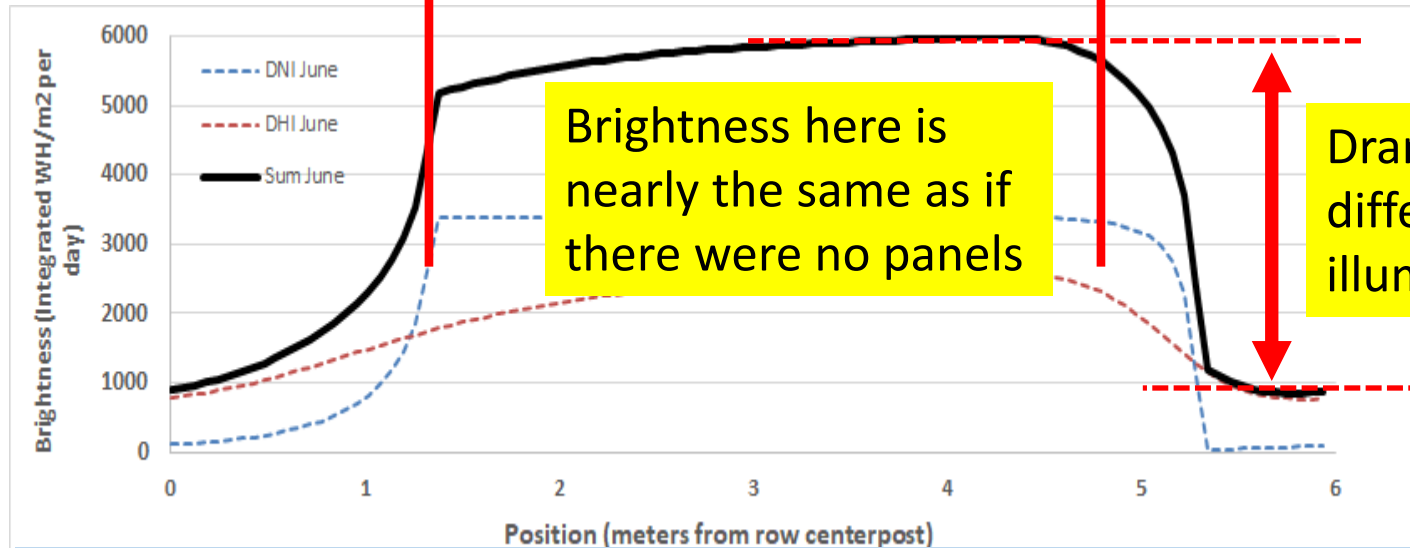
Fixed Tilt Arrays

GCR = 0.333
W:H:S = 2:1:6
Drawn to scale
June



SOUTH

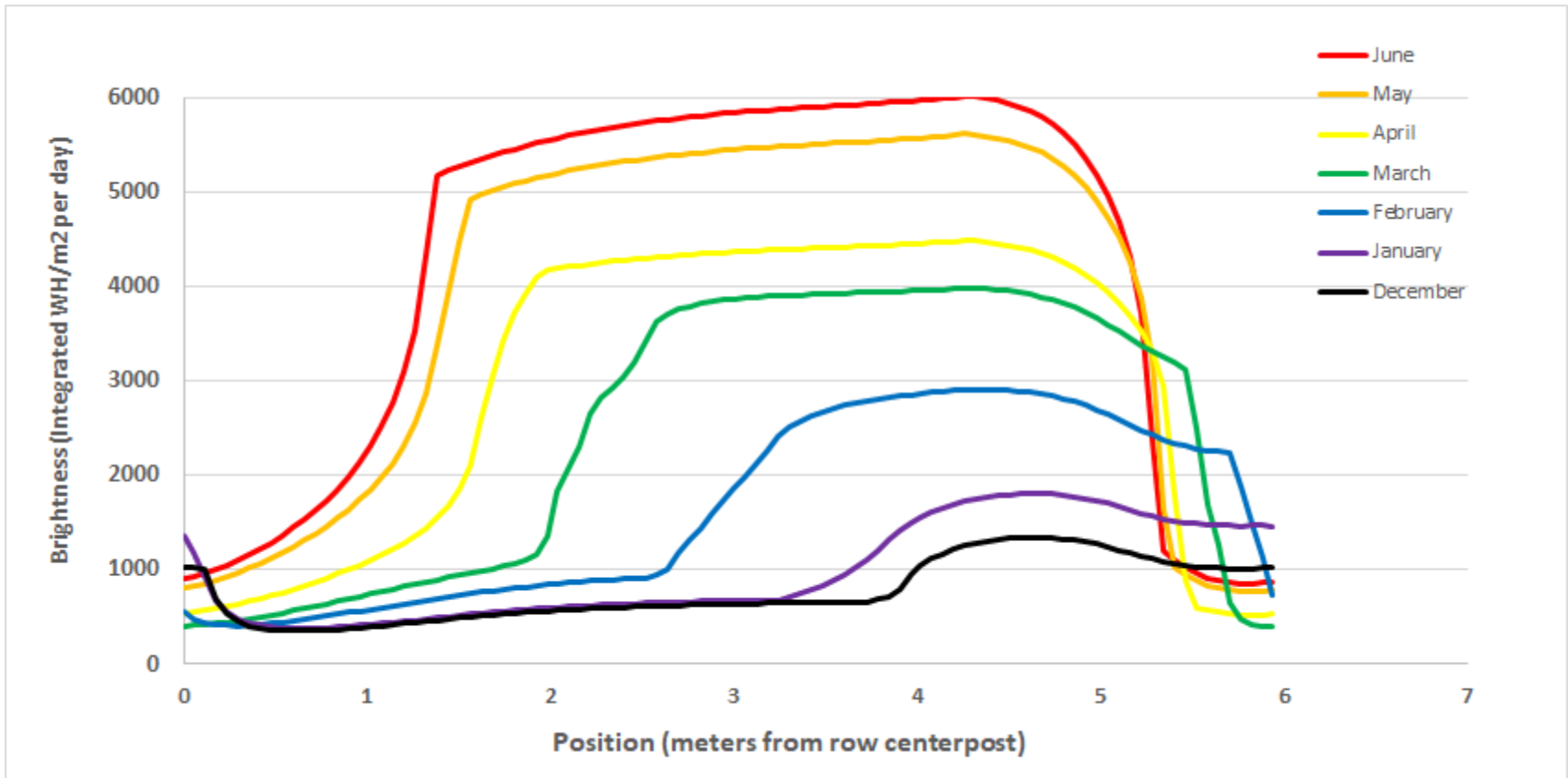
NORTH



Optimal Tilling Zone Shifts NORTH as Array Height Increases

Fixed Tilt Arrays

Seasonal Shading Patterns



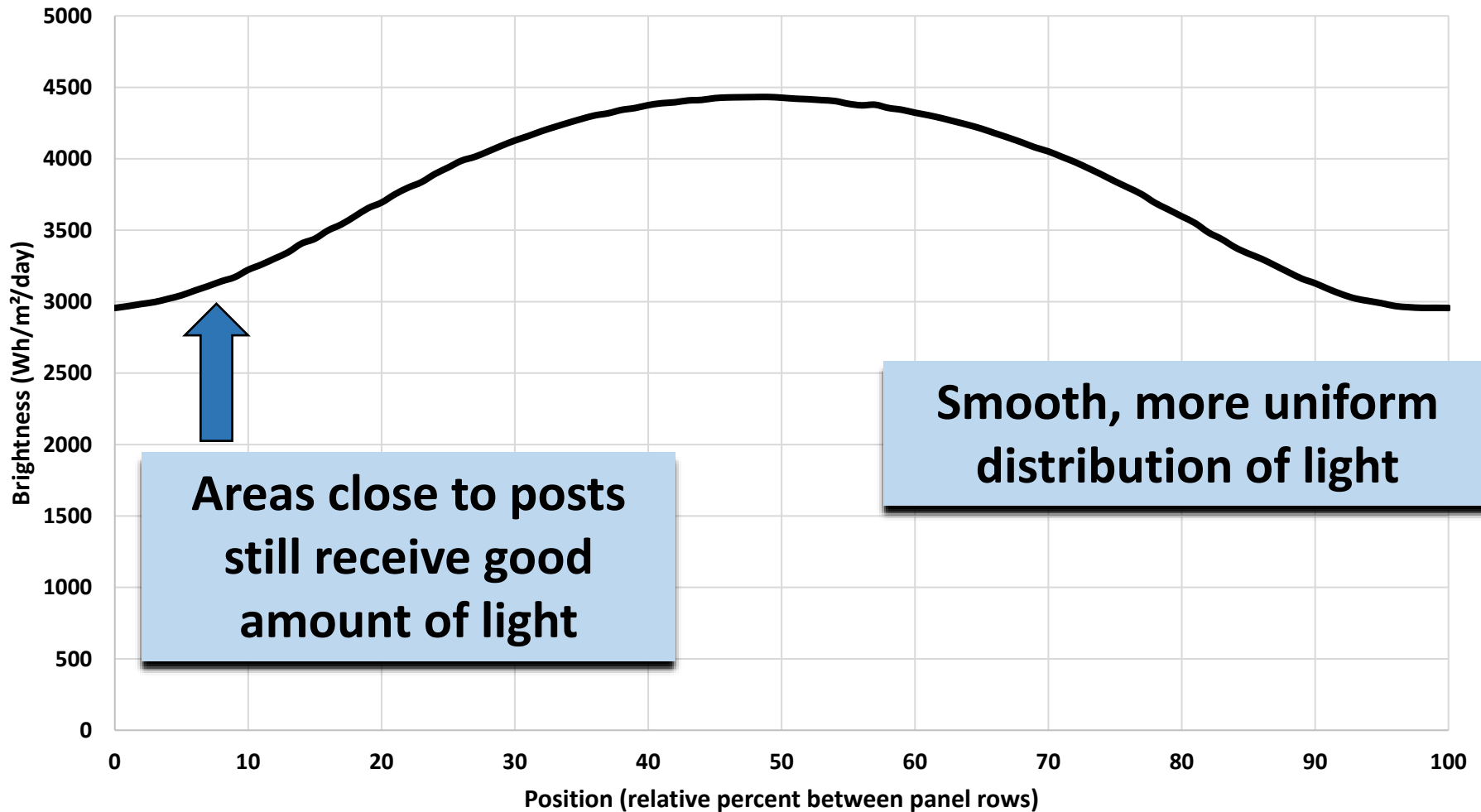
Significant seasonal shift and broadening of shadow

Snyder Farm – Tracking Array

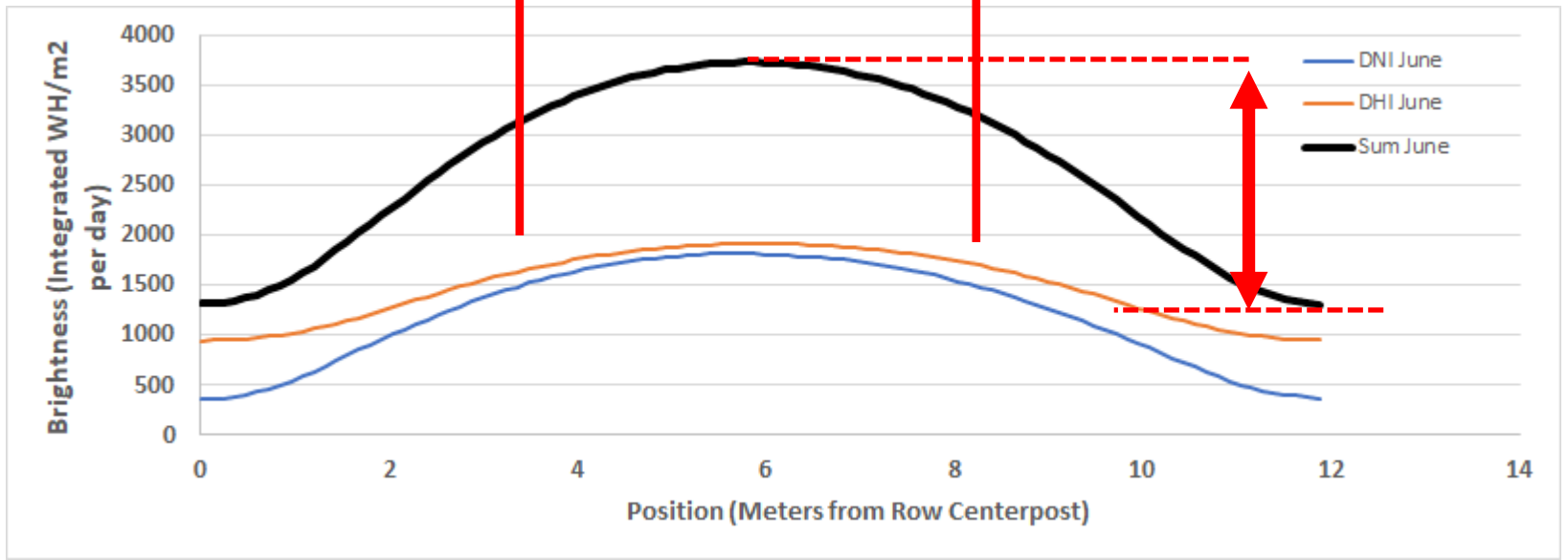
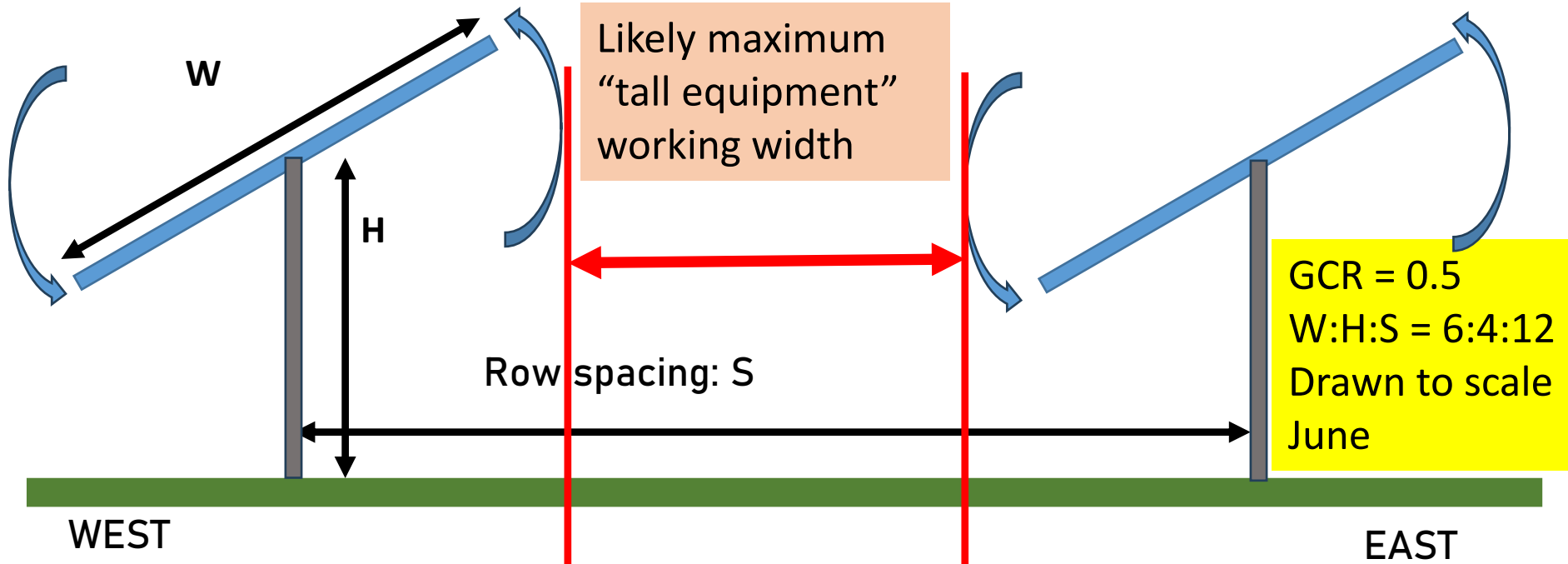


Single-Axis Tracking Arrays

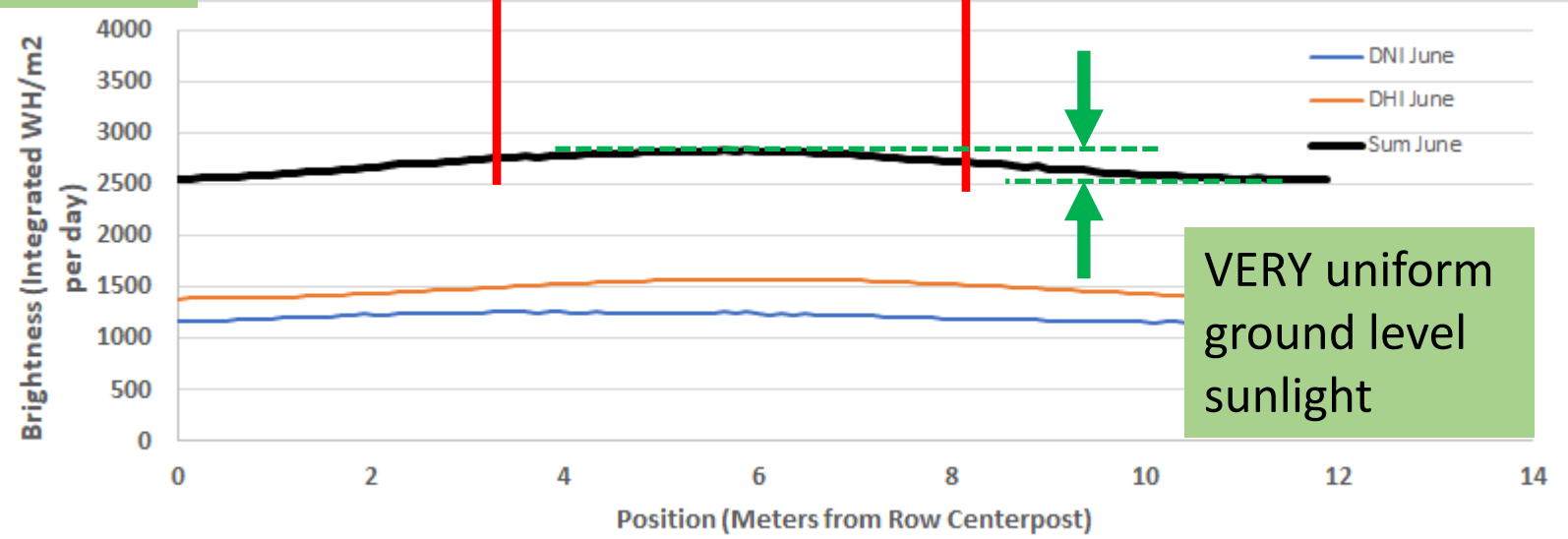
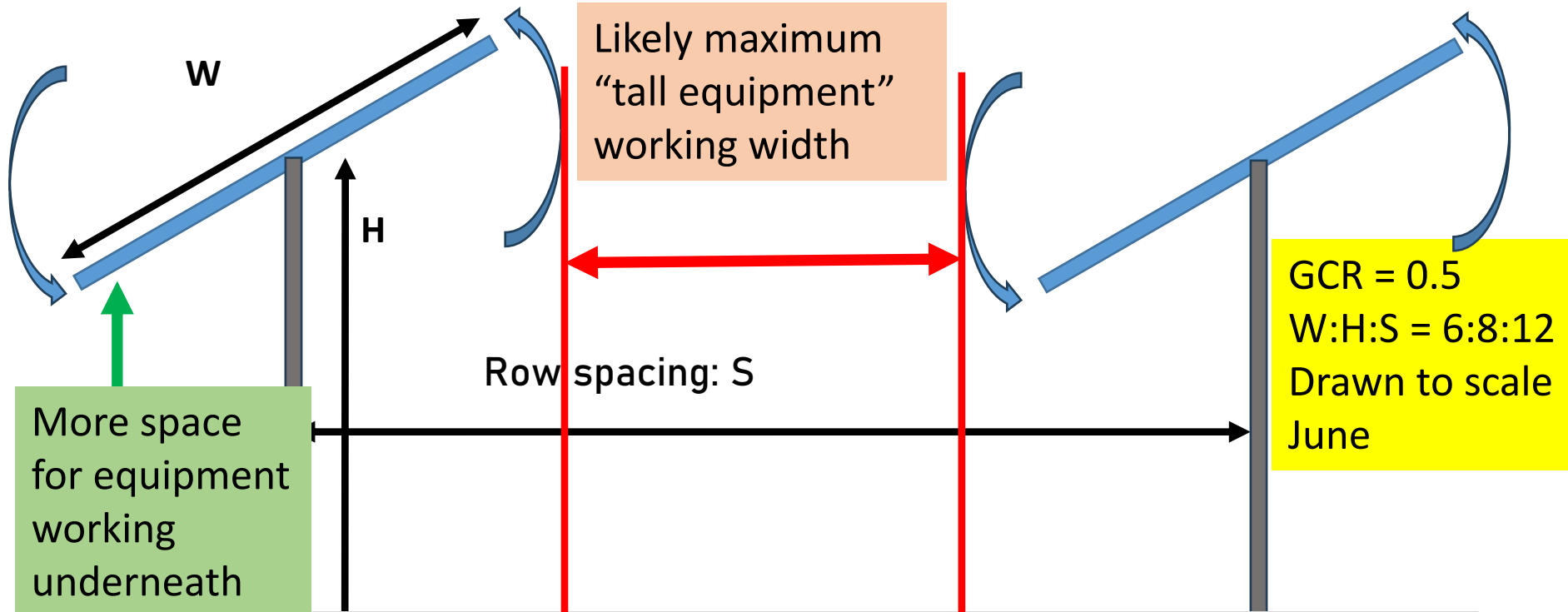
Shading Pattern for New Brunswick in June



Single-Axis Tracking Arrays



Single-Axis Tracking Arrays



More space for equipment working underneath

Likely maximum "tall equipment" working width

$GCR = 0.5$
 $W:H:S = 6:8:12$
Drawn to scale
June

VERY uniform ground level sunlight

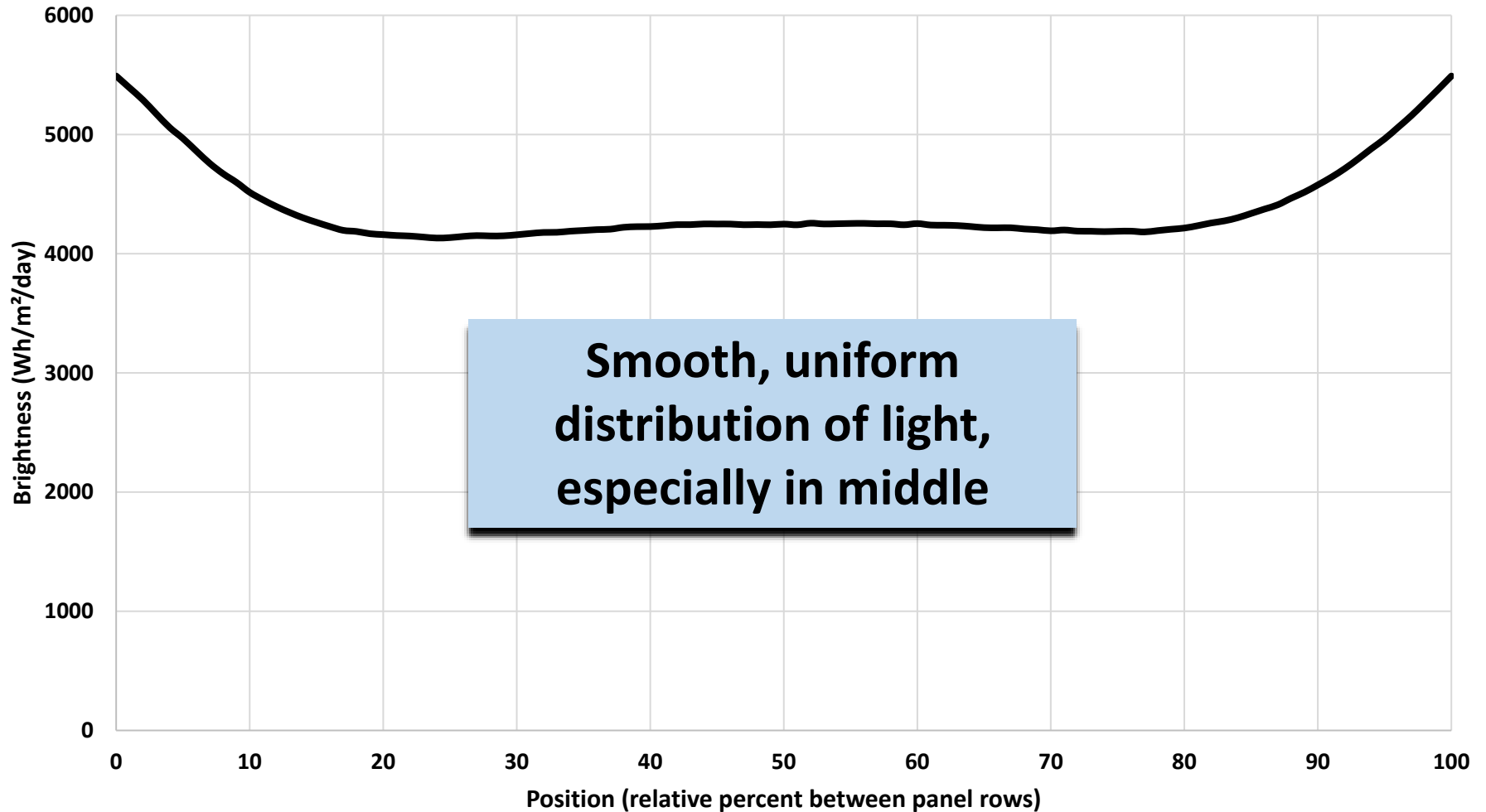
WE

Vertical Bifacial Arrays

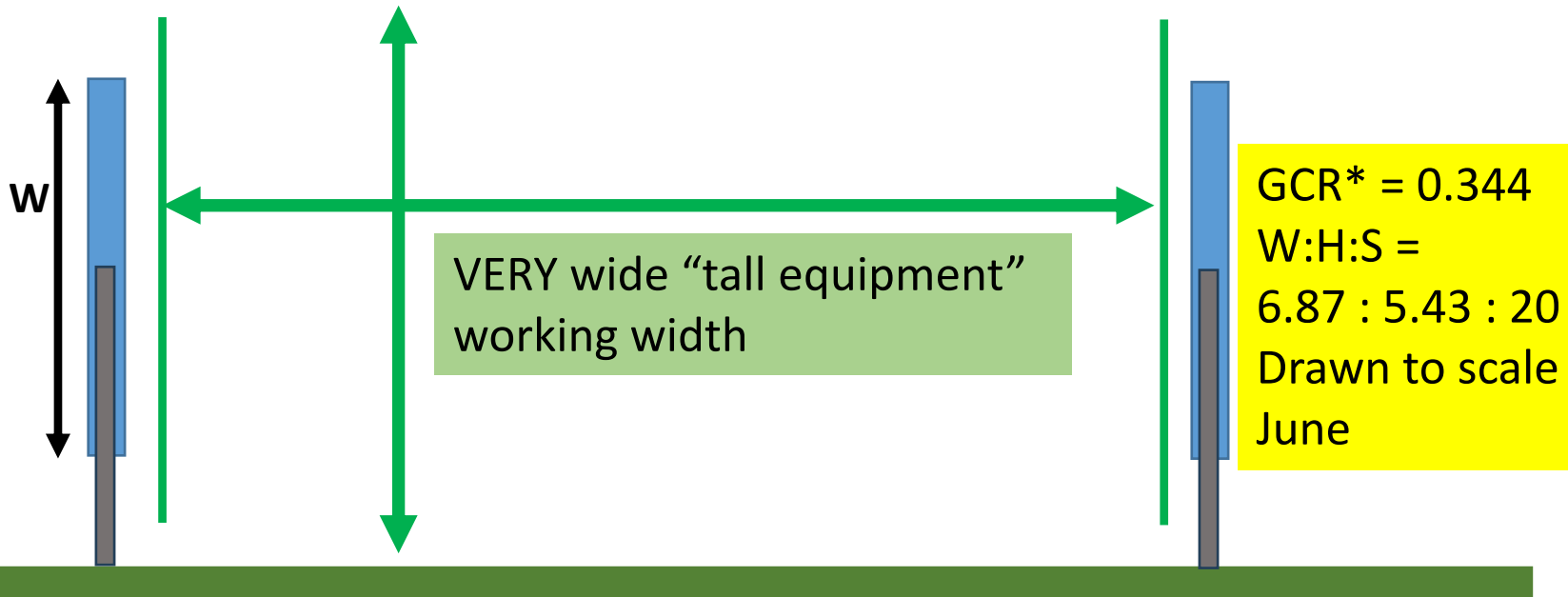


Vertical Bifacial Arrays

Shading Pattern for New Brunswick in June

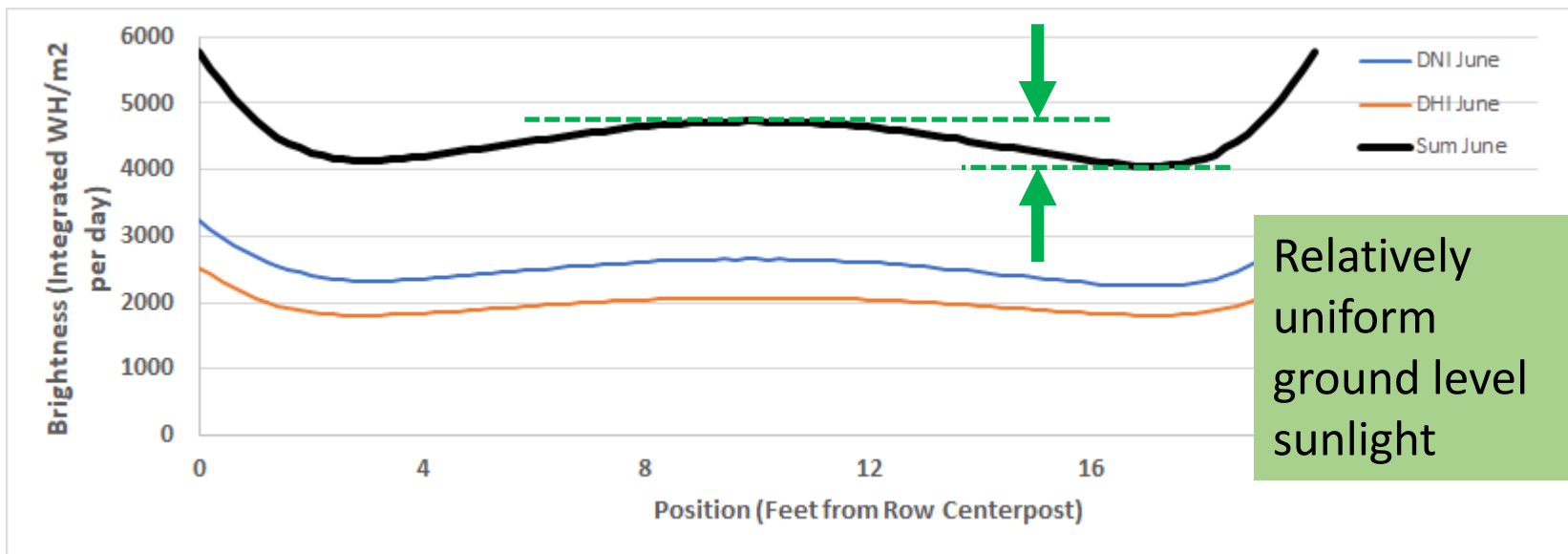


Vertical Bifacial Arrays



WEST

EAST

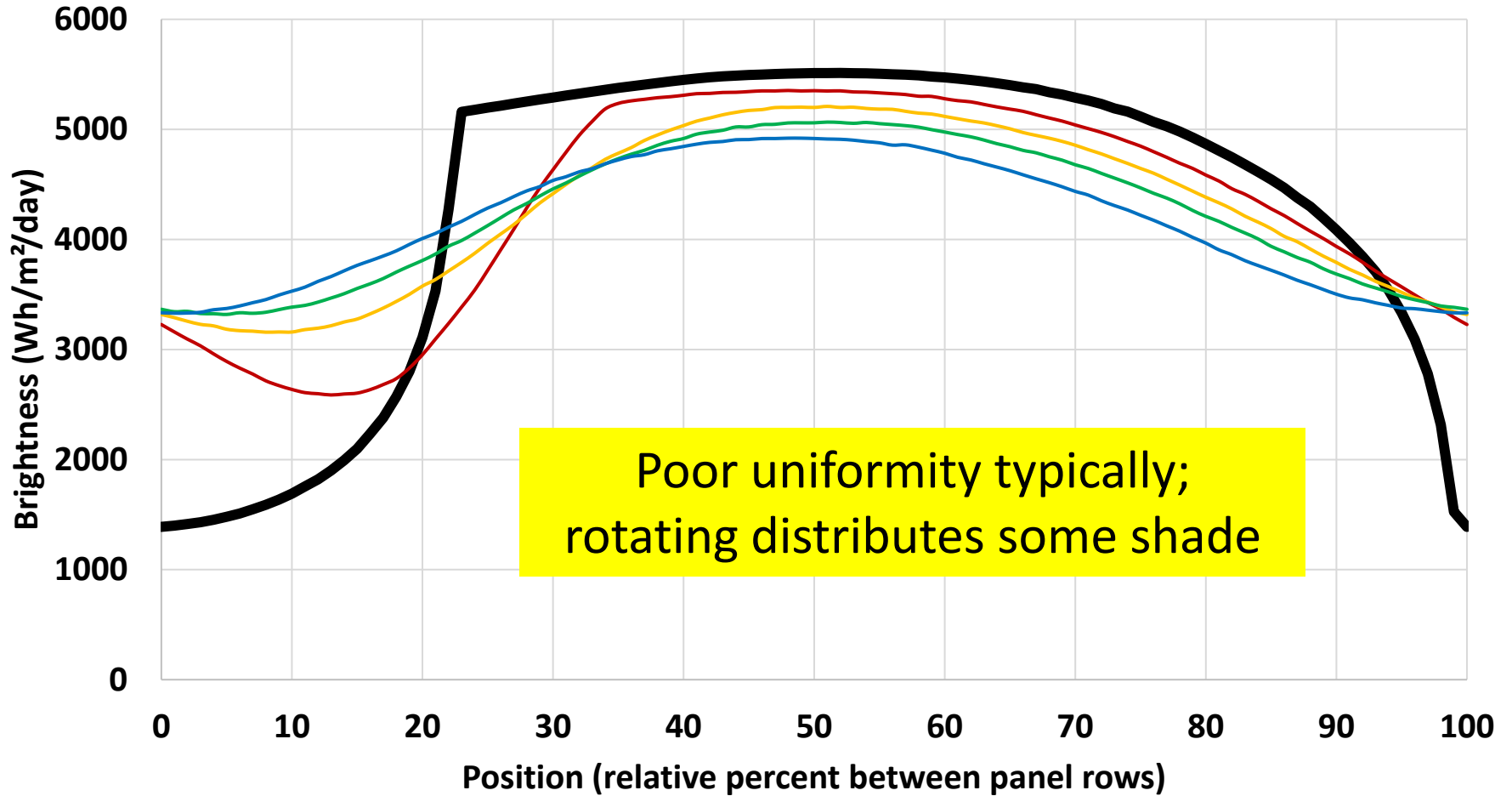


Rotating Your Array



Rotating Your Array

Fixed Tilt



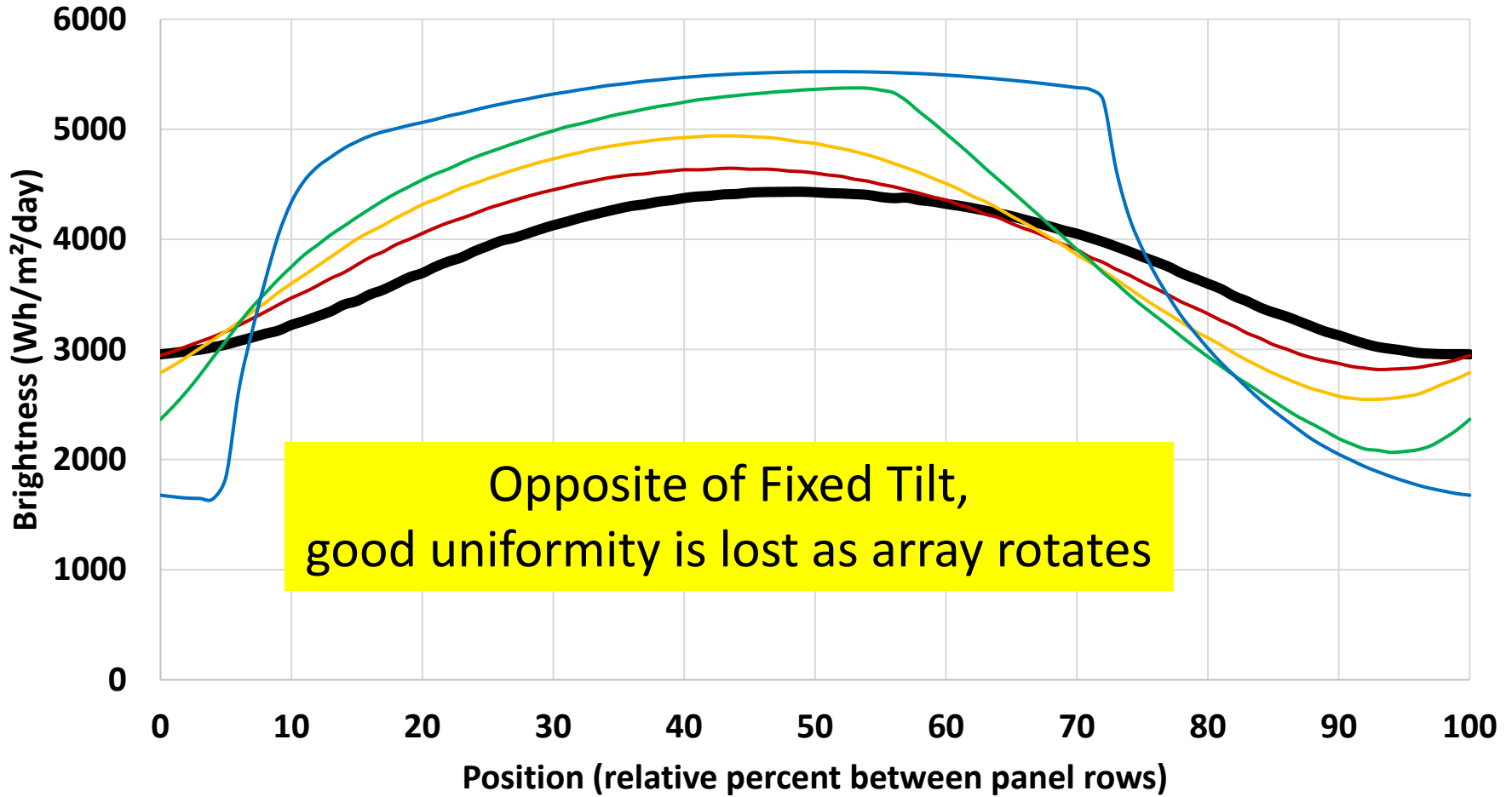
Poor uniformity typically;
rotating distributes some shade

— 0° — 30° — 45° — 60° — 90°

Uniformity = 65% 77% 83% 85% 86%

Rotating Your Array

Single-Axis Tracking



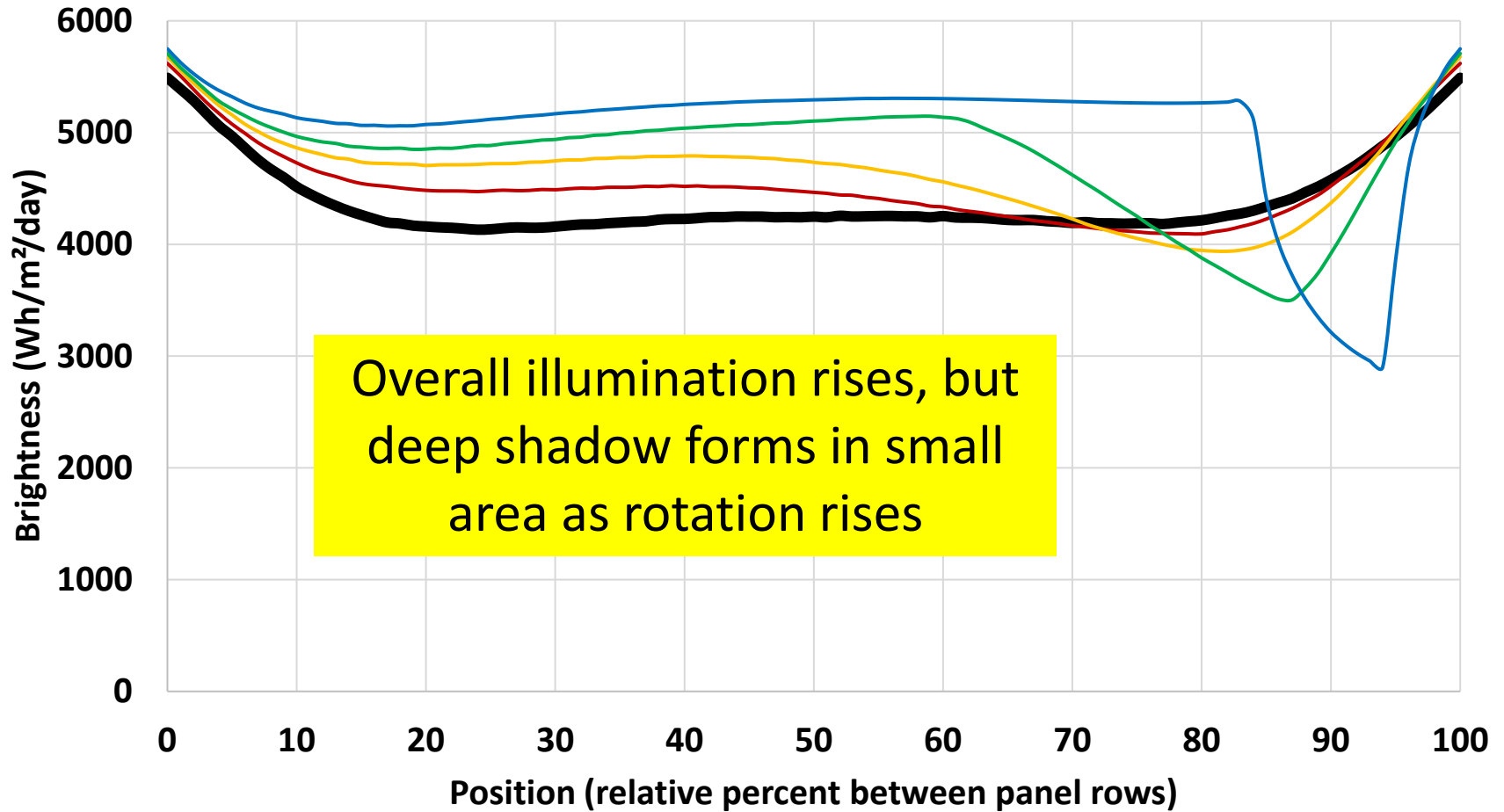
Opposite of Fixed Tilt,
good uniformity is lost as array rotates

— 0° — 30° — 45° — 60° — 90°

Uniformity = 86% 83% 78% 71% 65%

Rotating Your Array

Vertical Bifacial



Overall illumination rises, but deep shadow forms in small area as rotation rises

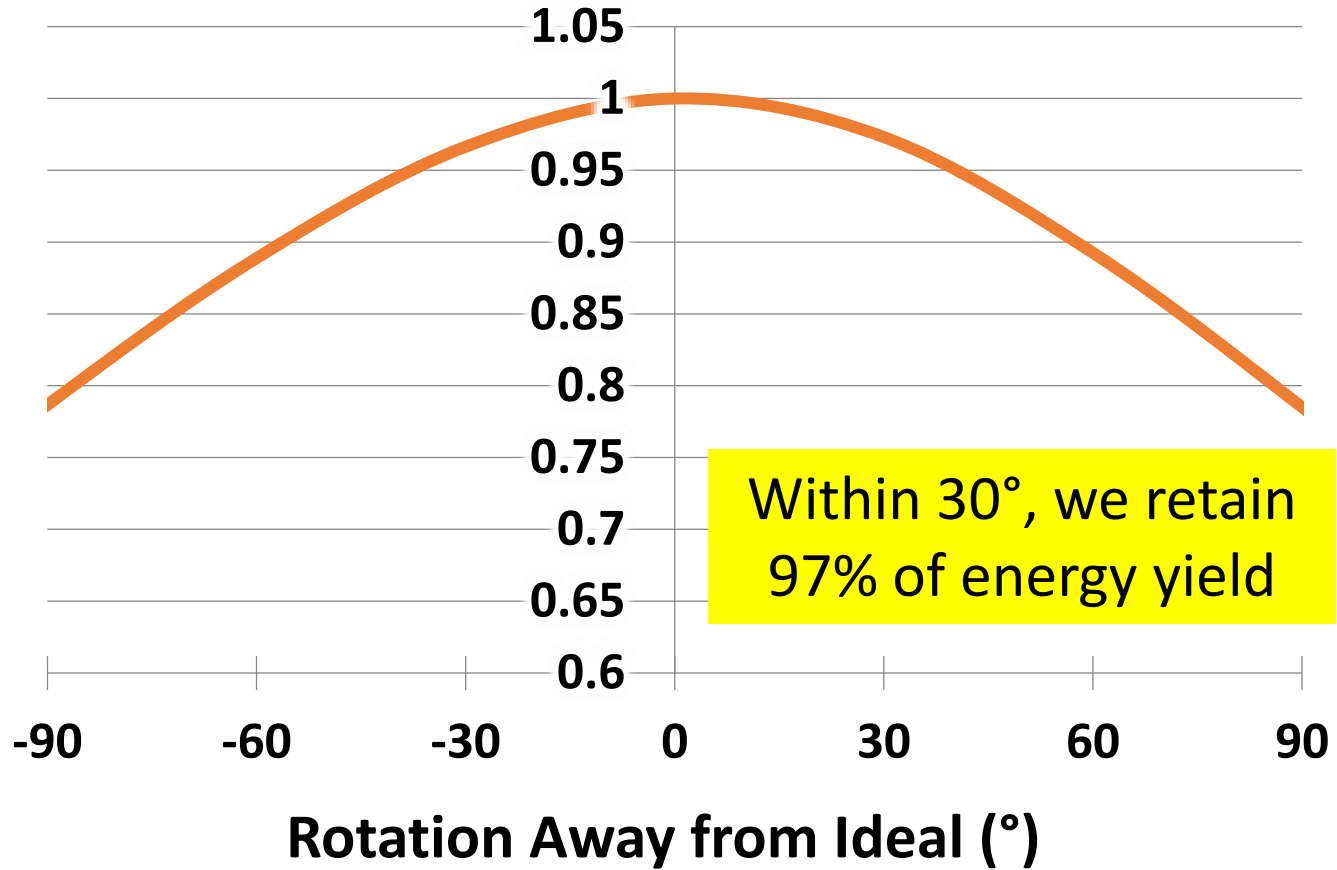
— 0° — 30° — 45° — 60° — 90°

Uniformity = 92% 92% 91% 89% 88%

Rotating Your Array

Fixed Tilt

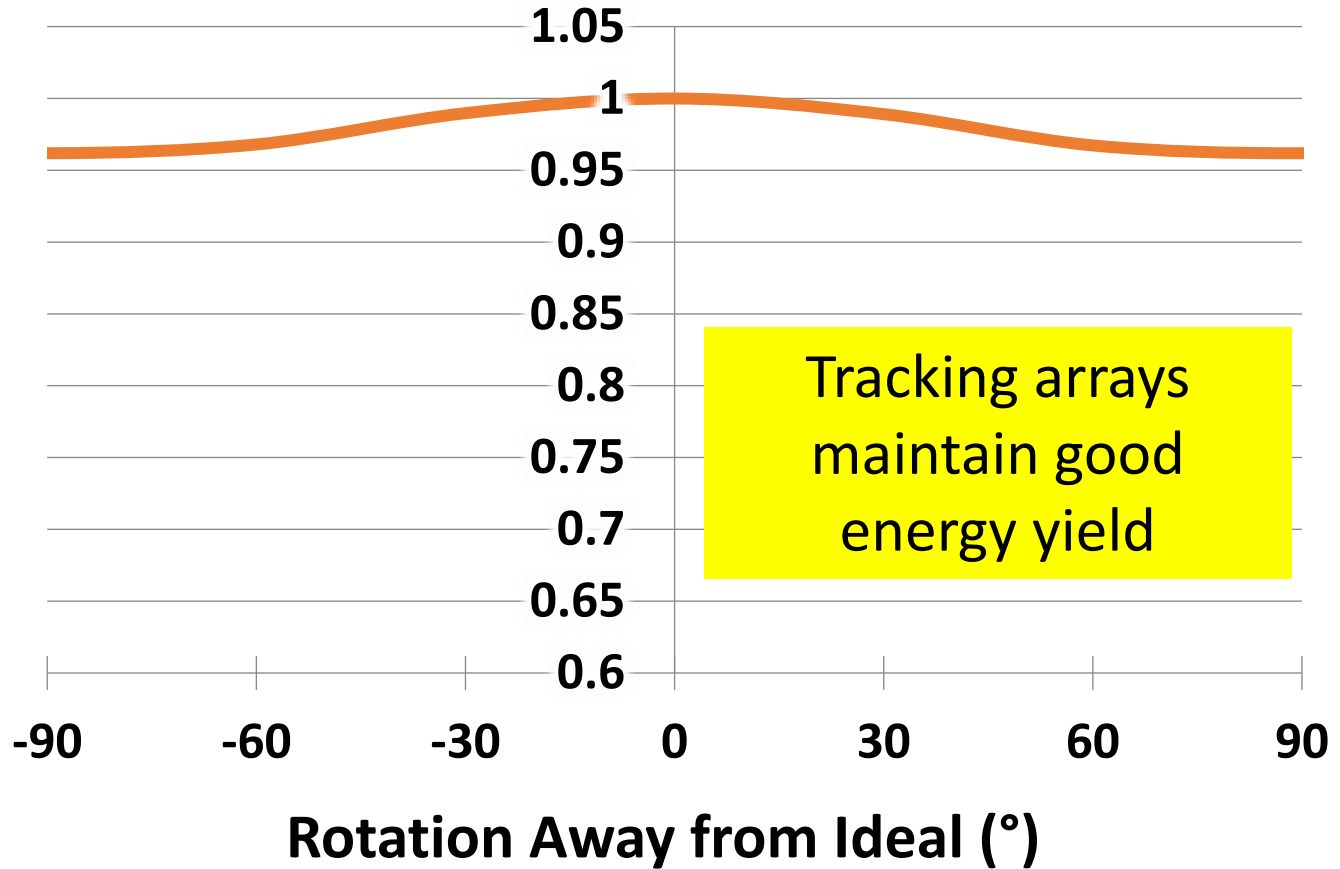
Fraction of Annual Energy
Produced Relative to Ideal



Rotating Your Array

Single-Axis Tracking

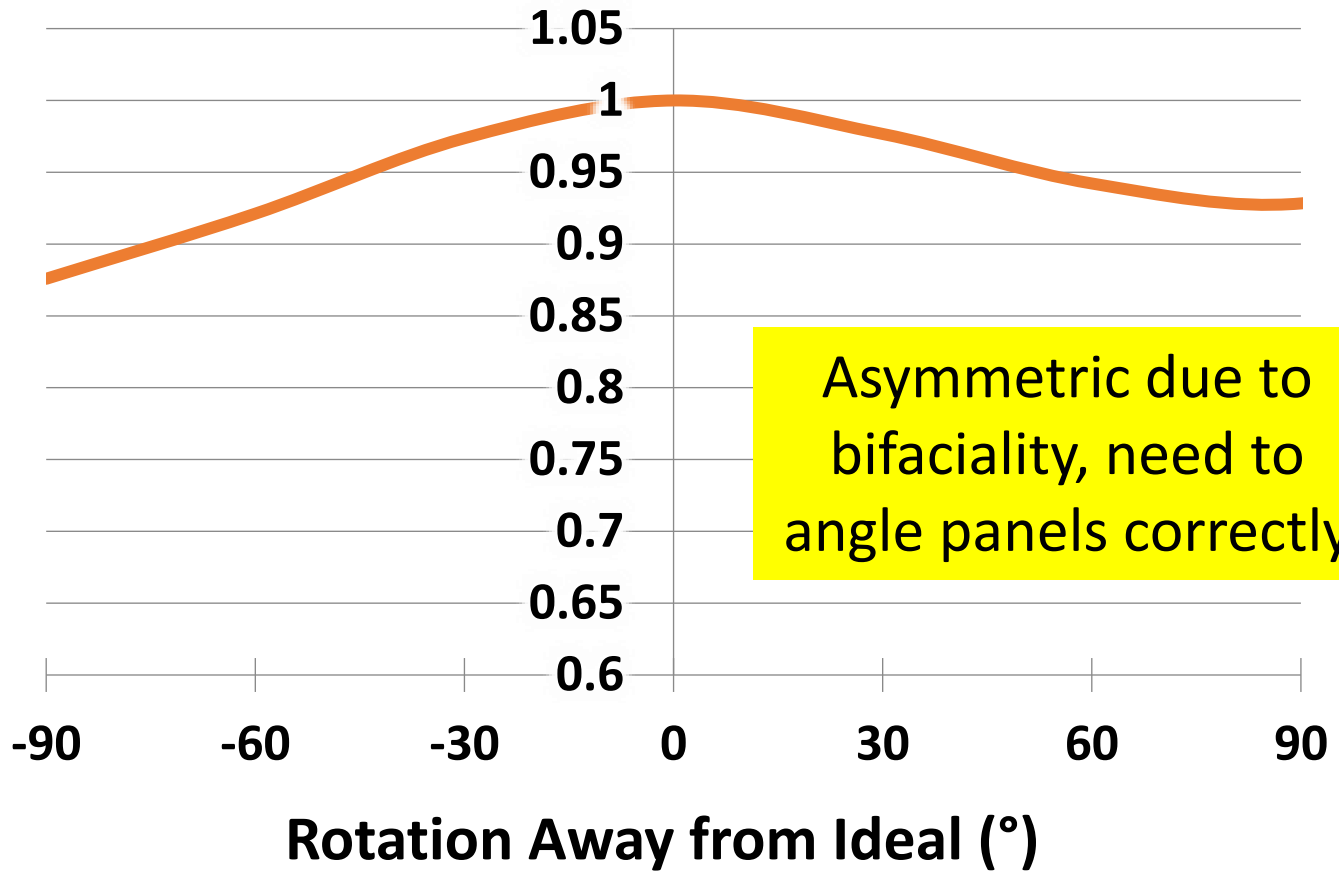
**Fraction of Annual Energy
Produced Relative to Ideal**



Rotating Your Array

Vertical Bifacial

**Fraction of Annual Energy
Produced Relative to Ideal**



Asymmetric due to
bifaciality, need to
angle panels correctly

Key Things to Consider, Questions to Ask

- ❑ What array type works best for you?
 - Cost to install
 - Energy produced
 - Construction concerns
- ❑ How far apart should the rows be spaced?
 - Large machinery
 - Light requirements for crops
- ❑ How high up should the panels be installed?
- ❑ Do you need to rotate the array to fit the features of your plot of land?