Accuracy and Uncertainty in Shading Calculations for Solar Power

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Importance of Project

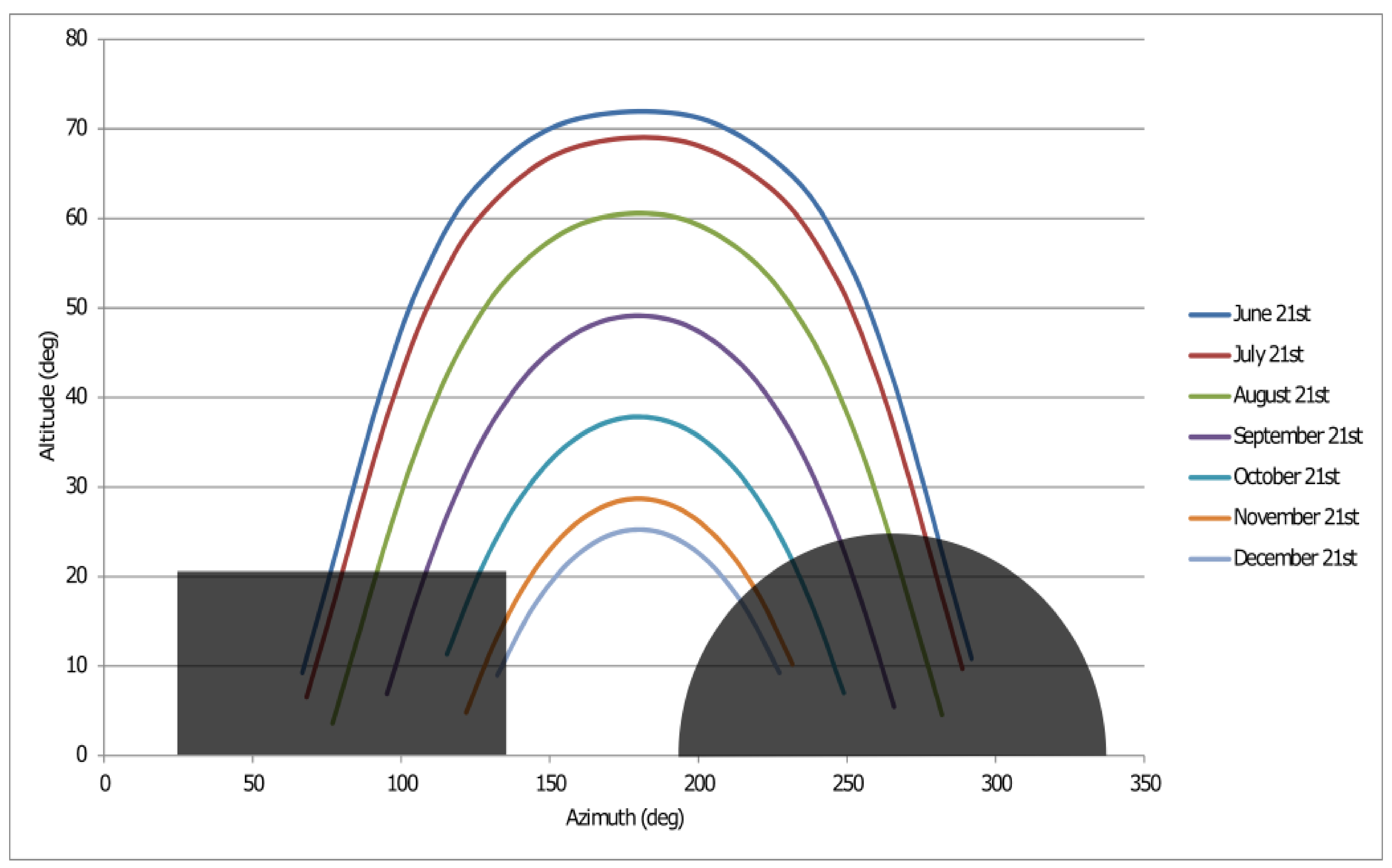
- How much do measurement errors of the horizon affect the estimation of the annual energy production?
  - Upfront costs deter the use of alternative energy
  - This issue can be addressed by maximizing the output energy of solar panels
  - Simulations can predict the output power at a location
  - Local obstructions on the horizon cause shading, reducing the output
  - We consider the reductions in production due to virtual horizons with simulated measurement error

SAM and Java Implementation

- System Advisor Model (SAM) simulates photovoltaic systems
  - Irradiance on the collector
  - Electrical power generated
  - Expected payback time
- Developed Java application using SAM to simulate
  - Variable horizon shape
  - Variable horizon center, width, and height values

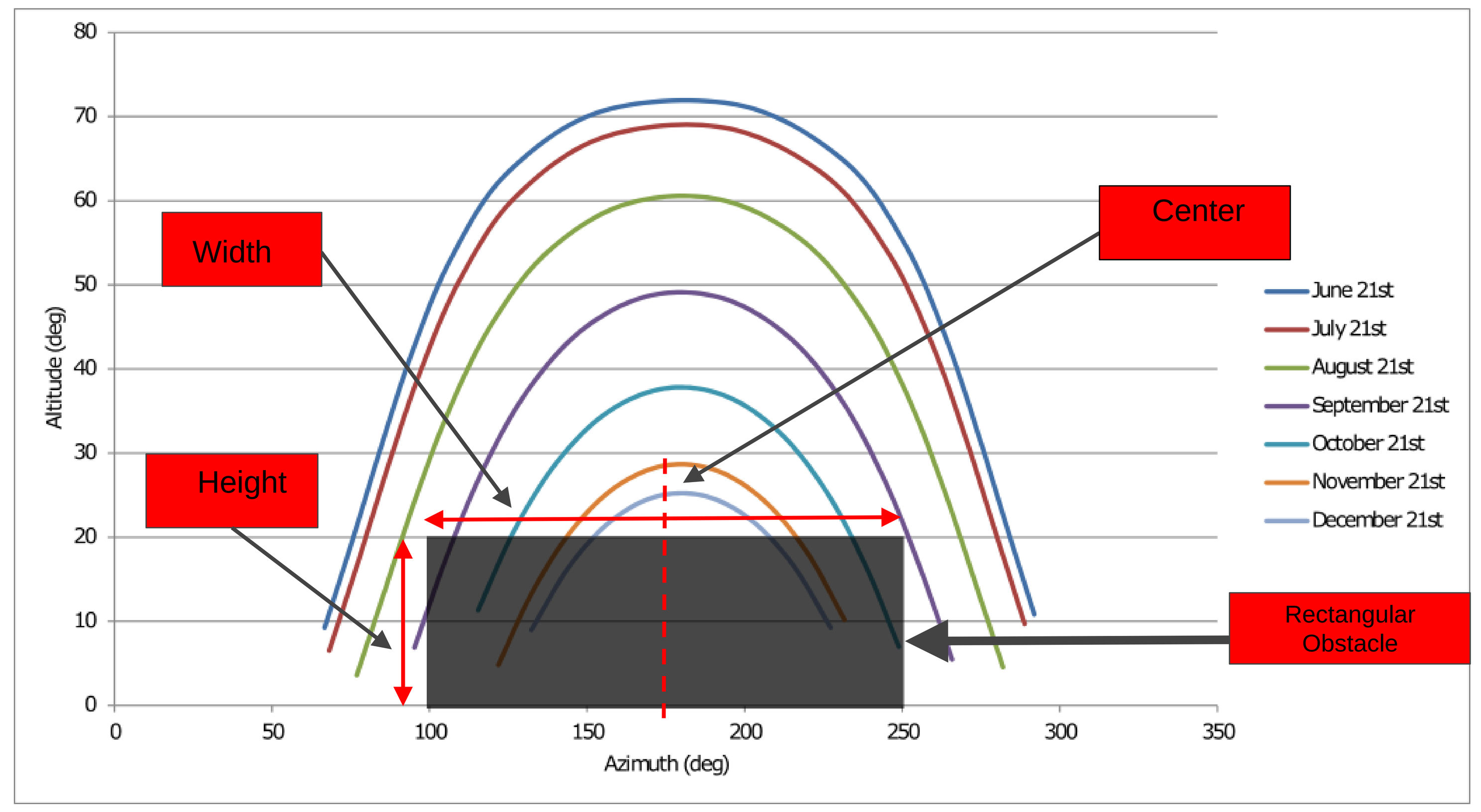
Definitions and Terms

- **Horizon Profile** - object locations that will potentially shade the panel
  - Used two generic horizon profiles: rectangular and parabolic
  - Simplified profiles provide building blocks for complex horizons
- **Sunchart** - visual representation of the sun's path in the sky throughout the year

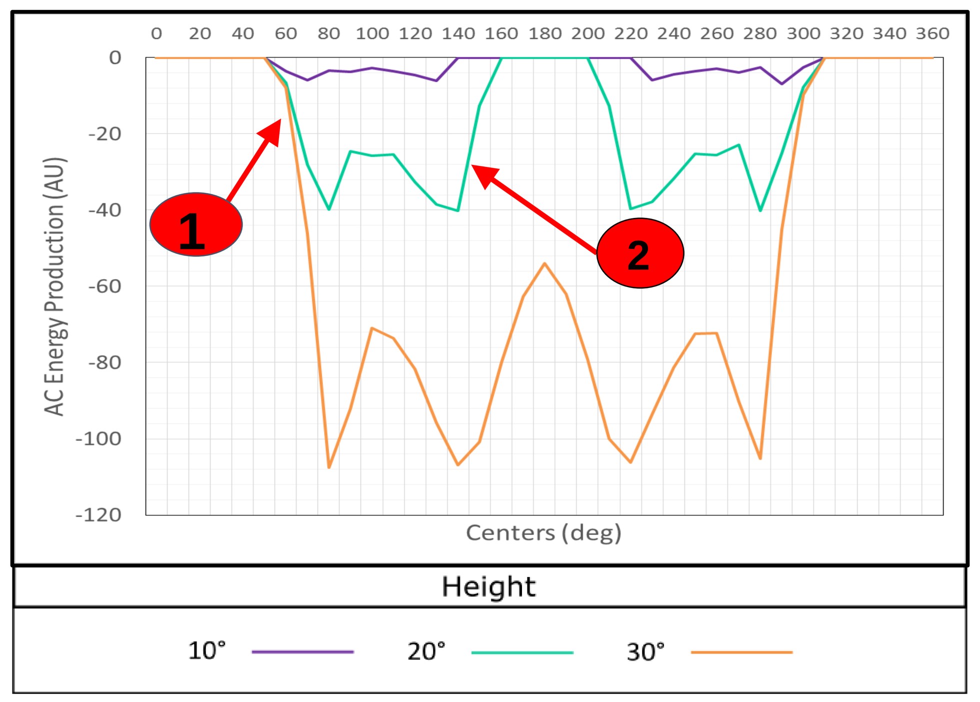


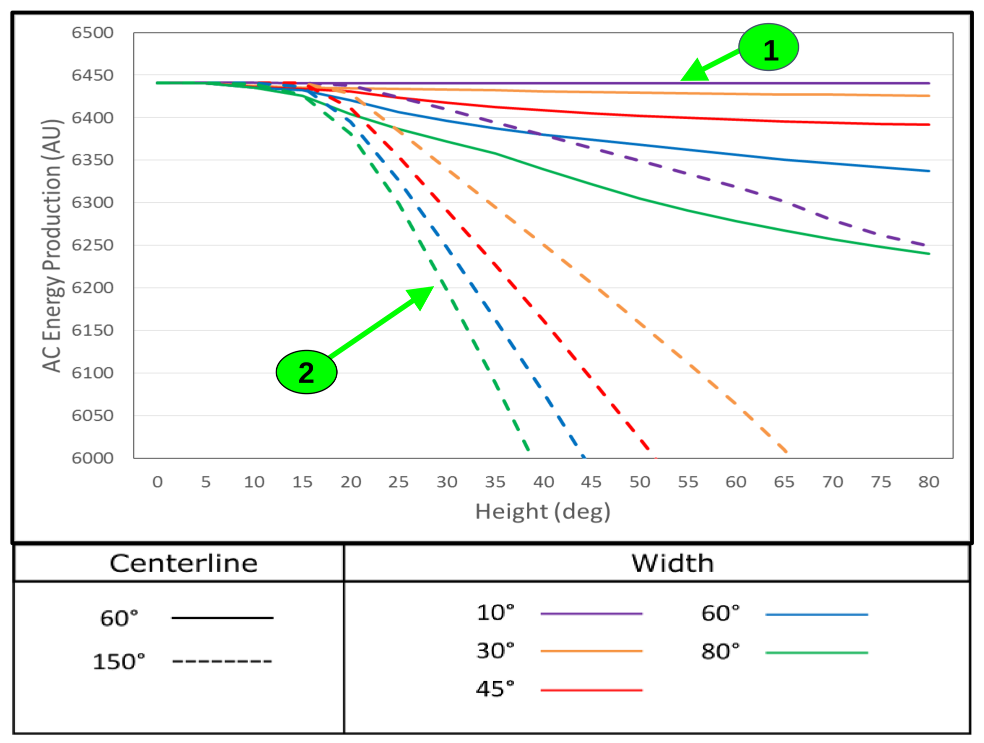
Testing for Shading

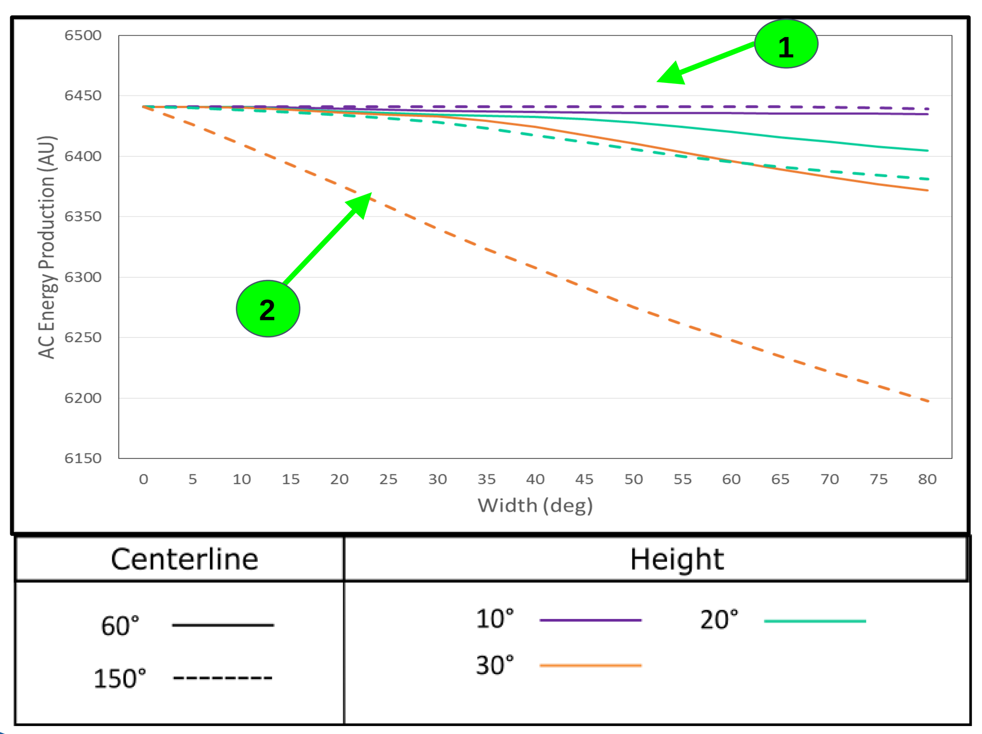
- Shading
  - Portions of sunchart covered by objects represent shaded hours
  - Area not covered by the object represents unshaded hours
- How are calculations done?
  - Identify whole hours when shading occur
  - Compute fractional hour by interpolation
  - Feed shading data into SAM
- What did we look for?
  - Reductions in annual energy output due to shading
  - Effects of variable horizon center, width, and height values
  - Sensitivity to movements in the obstacle position



Varying Centerline, Width, and Height







- Varied the centers in fine increments
- Normalized the results and scaled the graphs to compare directly
- Sharp peaks in the data represent object edges entering and exiting the sun's path
- (1) 60° center-line and (2) 150° center-line have the steepest slopes
  - Larger slope results in higher output error due to position error
- Measured the change in output power by varying:
  - The height of the obstacle(Graph 2)
  - The width of the obstacle (Graph 3)
- (1) Near zero slope shows the parameter having little effect on power output
- (2) Large slopes indicate a rapid change in output power
- Errors in height or width have much lower impact on power output than errors in center position

Results and Conclusion

- Center is the most sensitive to error
- Larger objects lead to higher sensitivity
- 0.056 percent per degree (%/deg) was the highest sensitivity observed
- Analysis quantifies the sensitivity of the output to each parameter

Future Plans

- Include meteorological data as another parameter
- Create a horizon profile using real-world observations
- Use various horizon survey tools and compare their uncertainties

References

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