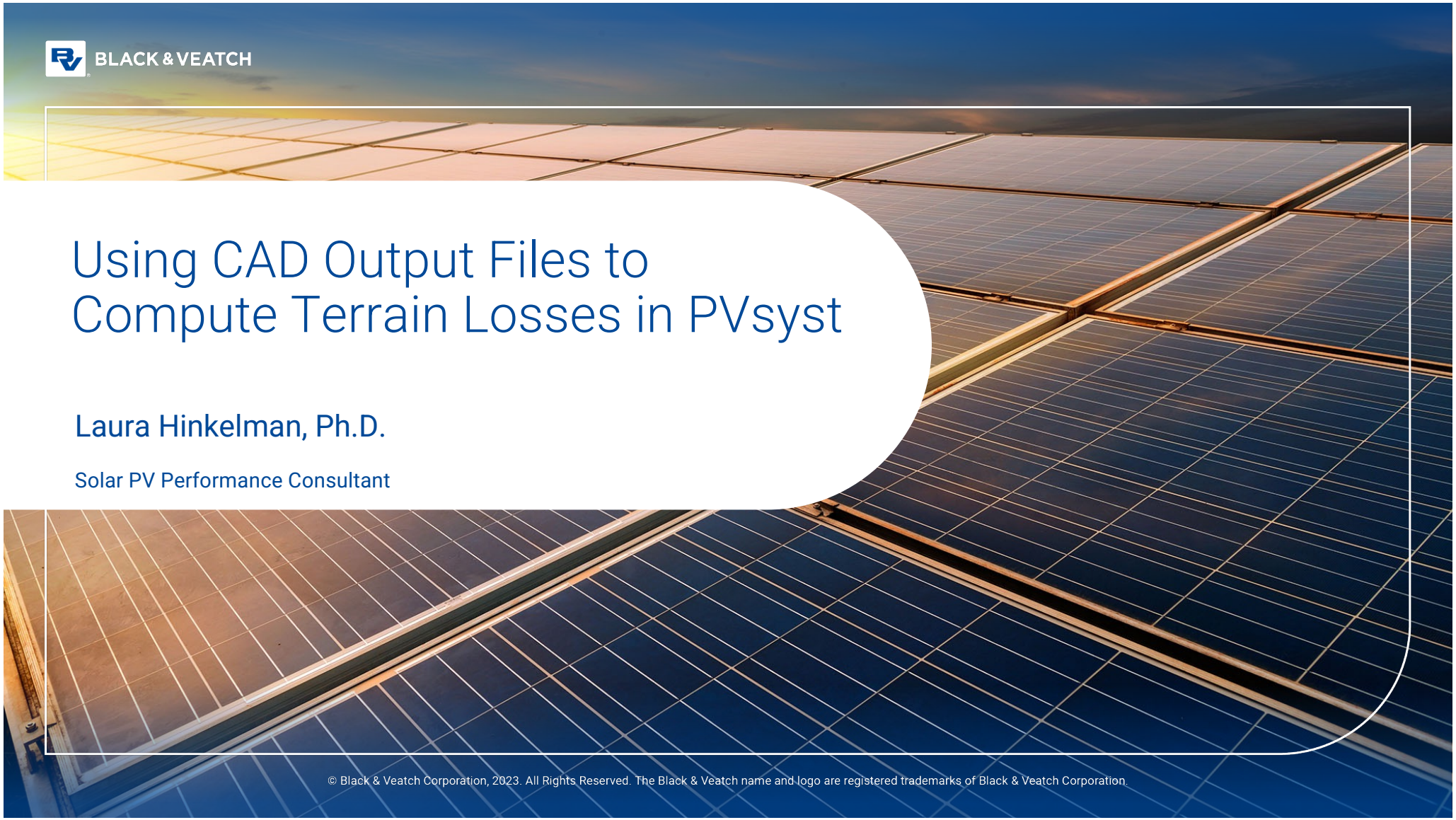

BLACK & VEATCH

Using CAD Output Files to Compute Terrain Losses in PVsyst

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Solar PV Performance Consultant

BLACK & VEATCH

Contributors:

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How do we model PV projects as they become more complicated?

➞ 3D scenes output from CAD systems as input to PVsyst

Review of slope effects

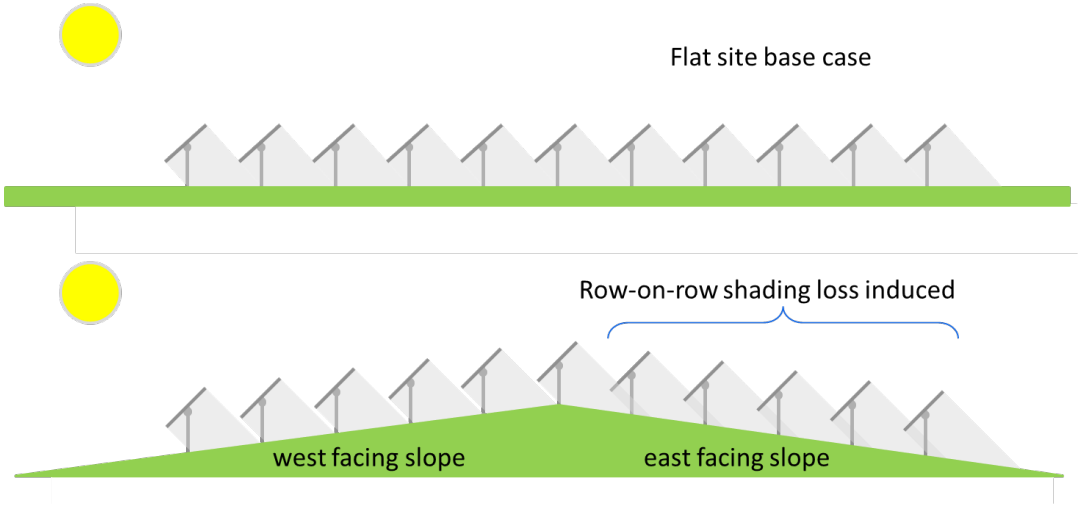
Using PVcase to create shading scenes including 3D topography

Benchmarking of performance estimates computed using these scenes.

Effect of Slopes

East-West slopes:

- Trackers on far side of hill are effectively closer together, leading to increased shading.
- Trackers on near side of hill are effectively farther apart.
- Slope effects do not cancel!



Effect of Slopes

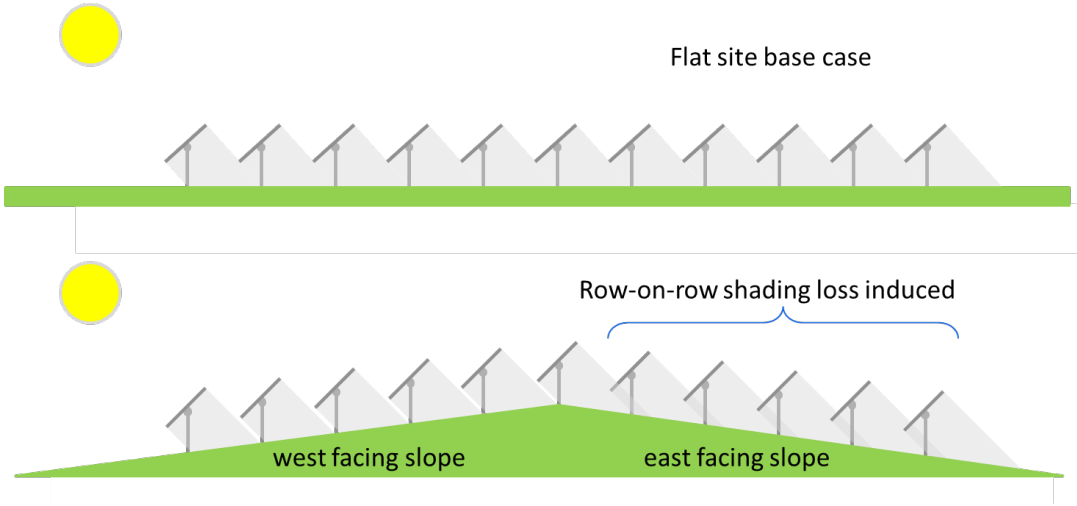
East-West slopes:

- Trackers on far side of hill are effectively closer together, leading to increased shading.
- Trackers on near side of hill are effectively farther apart.
- Slope effects do not cancel!

North-South slopes:

- Slight loss or gain.
- Slopes cancel.

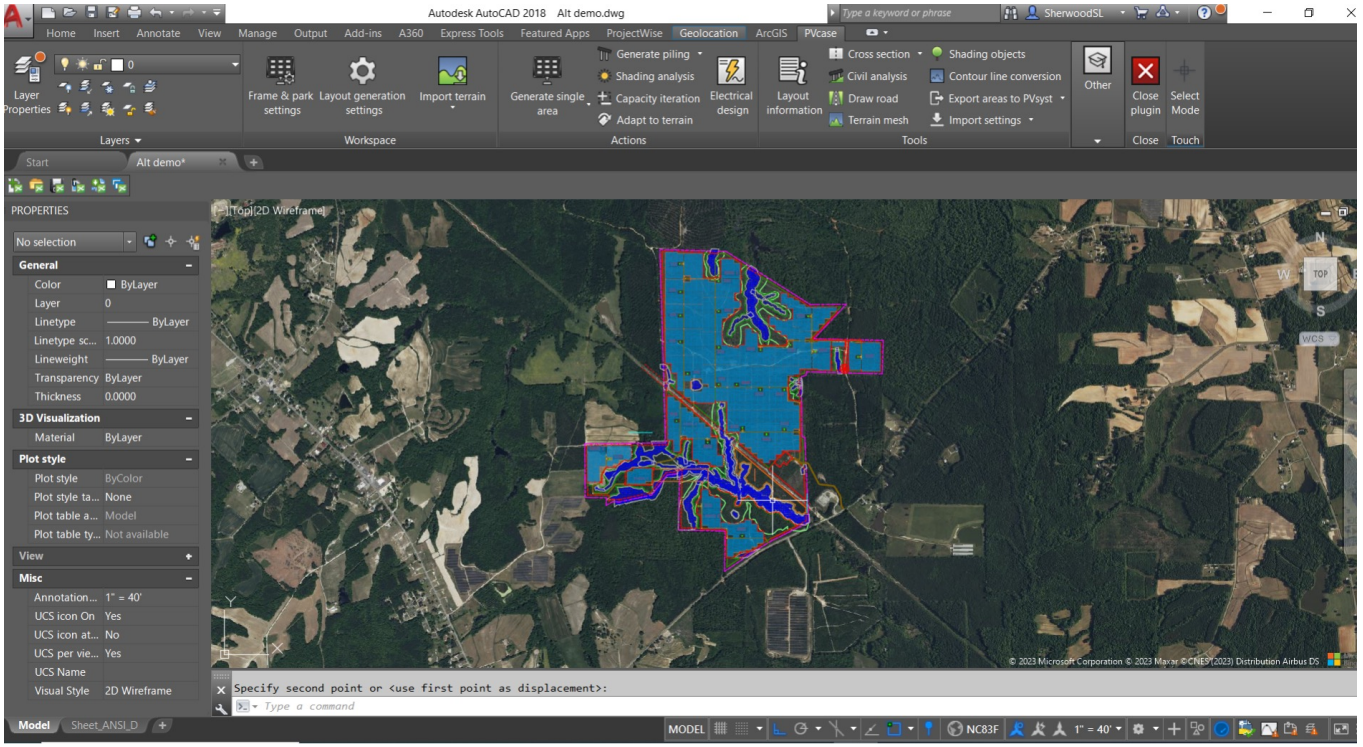
➡ Standard backtracking assumed.



PVcase Ground Mount

Bring in features from CAD
- Project boundaries
- Wetland delineation

Automatically lays out array

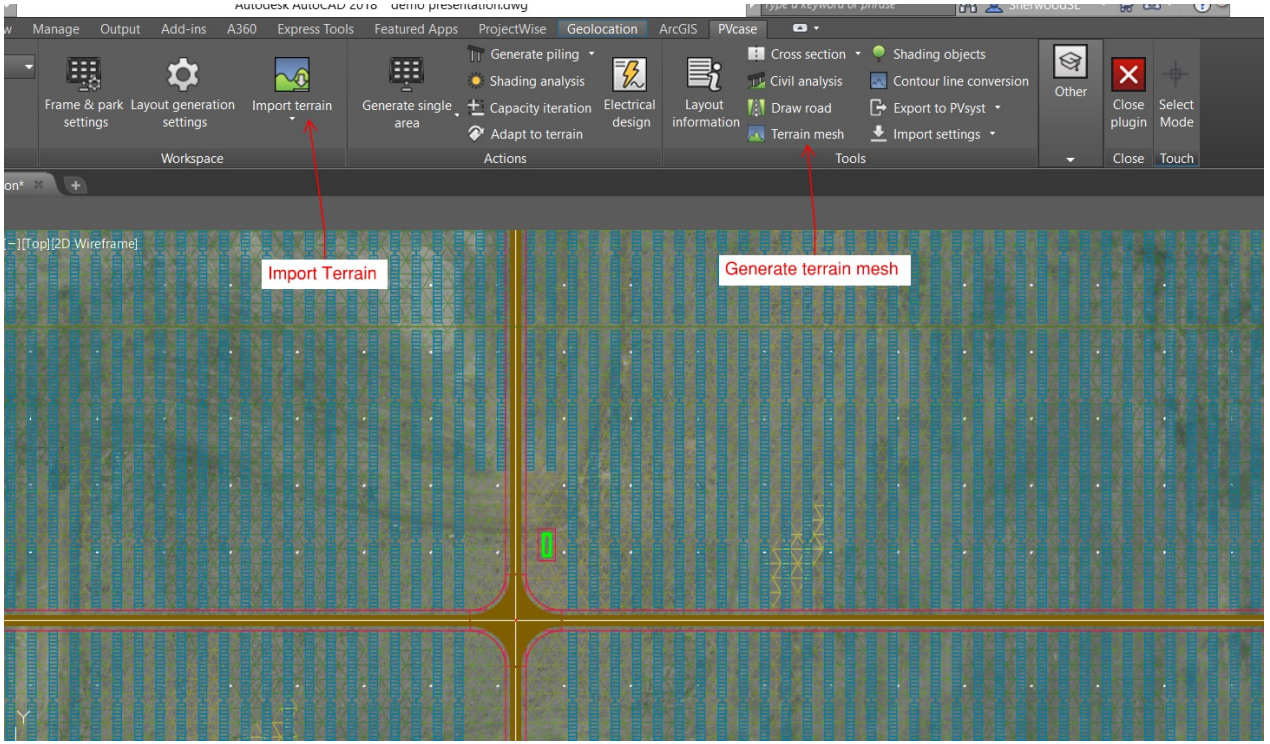


PVcase - terrain

Makes use of geolocation info in CAD file

Select from various DEM data sets

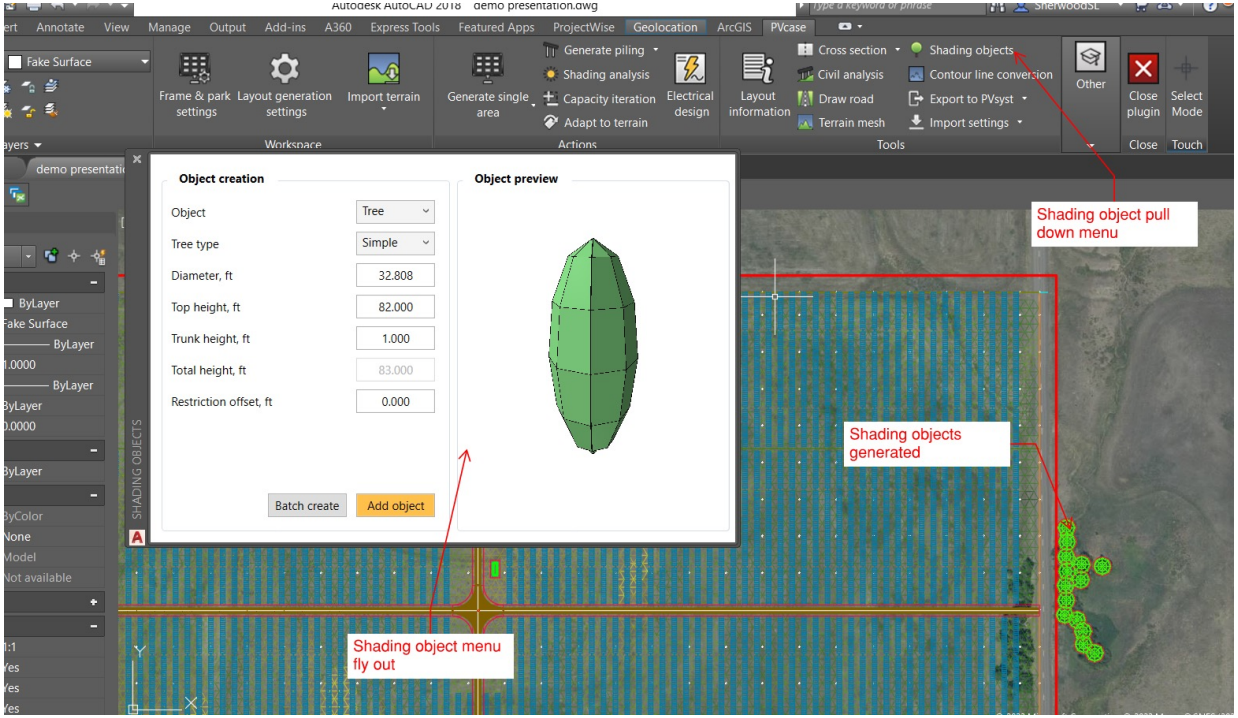
Creates a surface “mesh” to which objects are conformed.



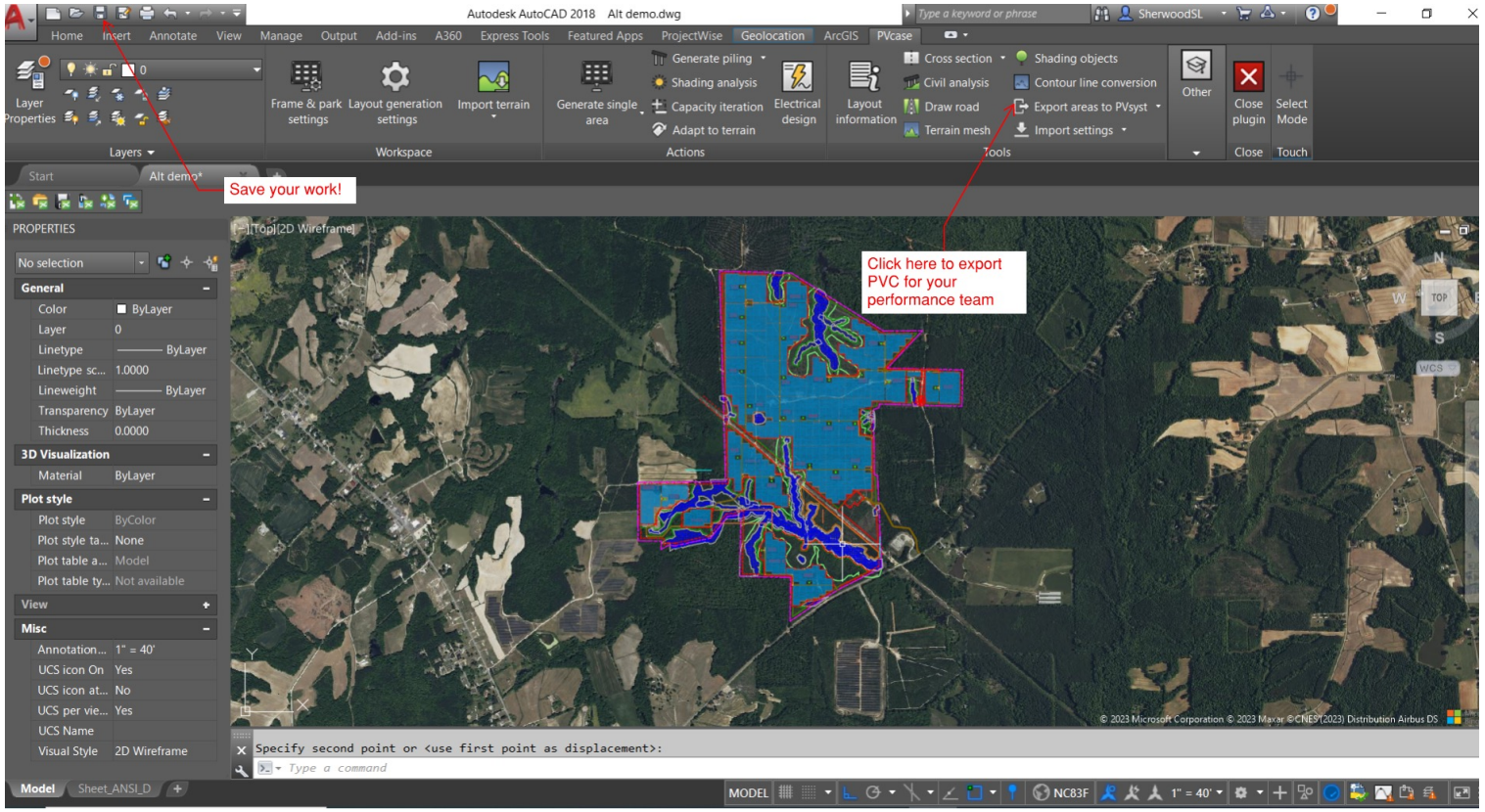
Shading objects

Various shading objects available, with scaling parameters.

Objects will be placed at correct elevation, according to the imported terrain.



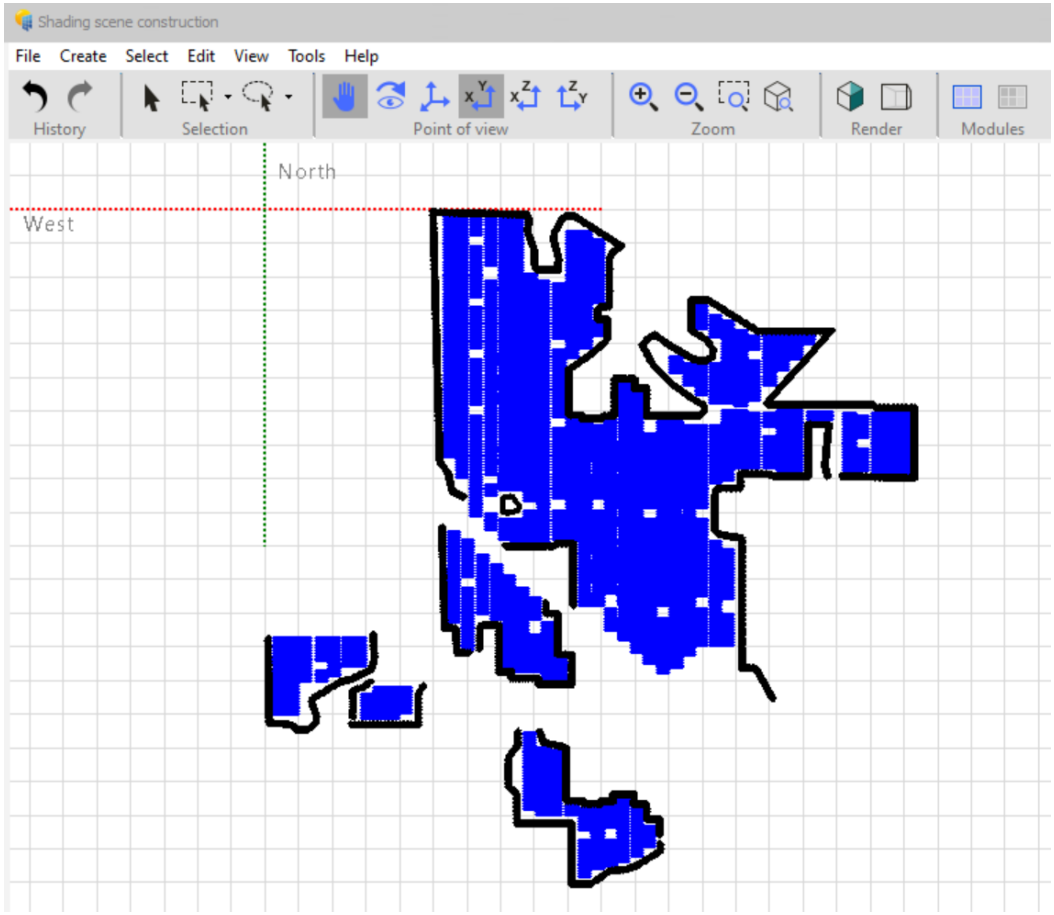
Save PVC file for PVsyst



PVcase scene in PVsyst

Includes all shading objects.

Modules are scaled to actual module size, no adjustments needed.

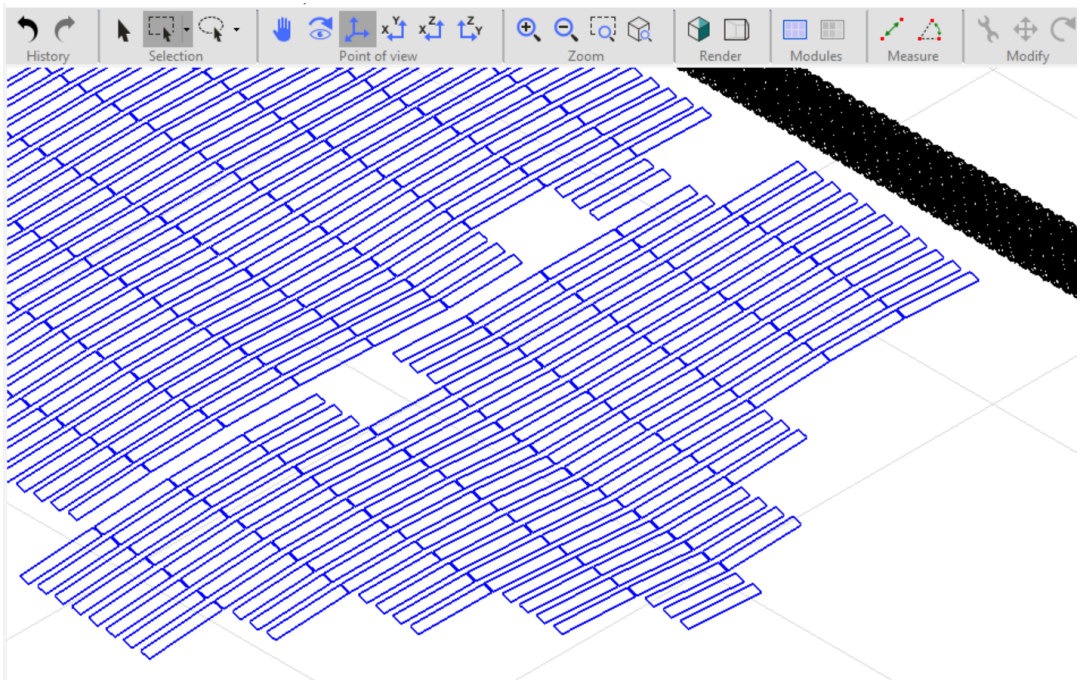


PVcase scene detail

Heights are correct, but no ground surface included

- Not needed for shading
- Racking height for bifacial calculation is entered with other bifacial parameters.
- Favors adding shading objects in PVcase.

Many objects included in scene.



Performance benchmarking: Slope losses

Five project examples

- One idealized system
- Four actual designs

Compare slope losses computed directly in PVsyst and using B&V-developed method.

Analyze as a function of location and weather.

Black & Veatch Slope Loss Algorithm

Developed and validated in cooperation with Nextracker

Basic method:

- Break down terrain according to direction of tilt
- Model multiple variants in PVsyst
- Synthesize results in proprietary post-processing

nextracker

Case Study: Beacon 5
nextracker.com

Independent Field Tests Confirm TrueCapture Boosts PV Plant Performance

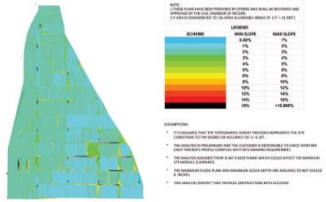
Project Overview

Built across the arid expanse of the Mojave Desert in Kern County north of Los Angeles, the 48 MW (DC) Beacon 5 solar power plant is one of five sites in the Beacon project portfolio, all of which feature Nextracker solar trackers. Completed and commissioned in 2017 with NX Horizon™ single-axis trackers and silicon full-cell modules, Beacon 5 has a ground cover ratio (GCR) of 50.48% and experiences an average of 26.39% diffuse light of the total solar resource. Given the undulating terrain and array layout, the site experienced significant row-to-row shading while operating with industry standard backtracking. Nextracker proposed implementing TrueCapture™, and the Beacon 5 site was upgraded in 2019 with software that utilizes both row-to-row and diffuse light optimization features.

Energy Yield Optimization Solution

With gigawatts already deployed globally, TrueCapture is Nextracker's smart tracker yield-optimization and control software. TrueCapture combines advanced sensing with machine-learning technologies to help mitigate energy losses and boost plant performance. TrueCapture continuously dispatches optimal tracking algorithms to each tracker row, correcting for inter-row shading anomalies caused by uneven ground and diffuse light conditions caused by cloudiness or haze. The increase in power production widens the "shoulders" of the power production curve for any given day, resulting in better performance, lower levelized cost of energy (LCOE), and maximized financial returns for the asset owner.

Name of project:	Beacon 5
Location:	Kern County, Mojave Desert, Calirfornia
Project Size:	48.2 MW (DC) 37.8 MW (AC)
Annual Energy Generated:	00.382 MWh
Owners:	Shikun & Binui and Ecofin
Offtaker:	L.A. Dept. of Water & Power



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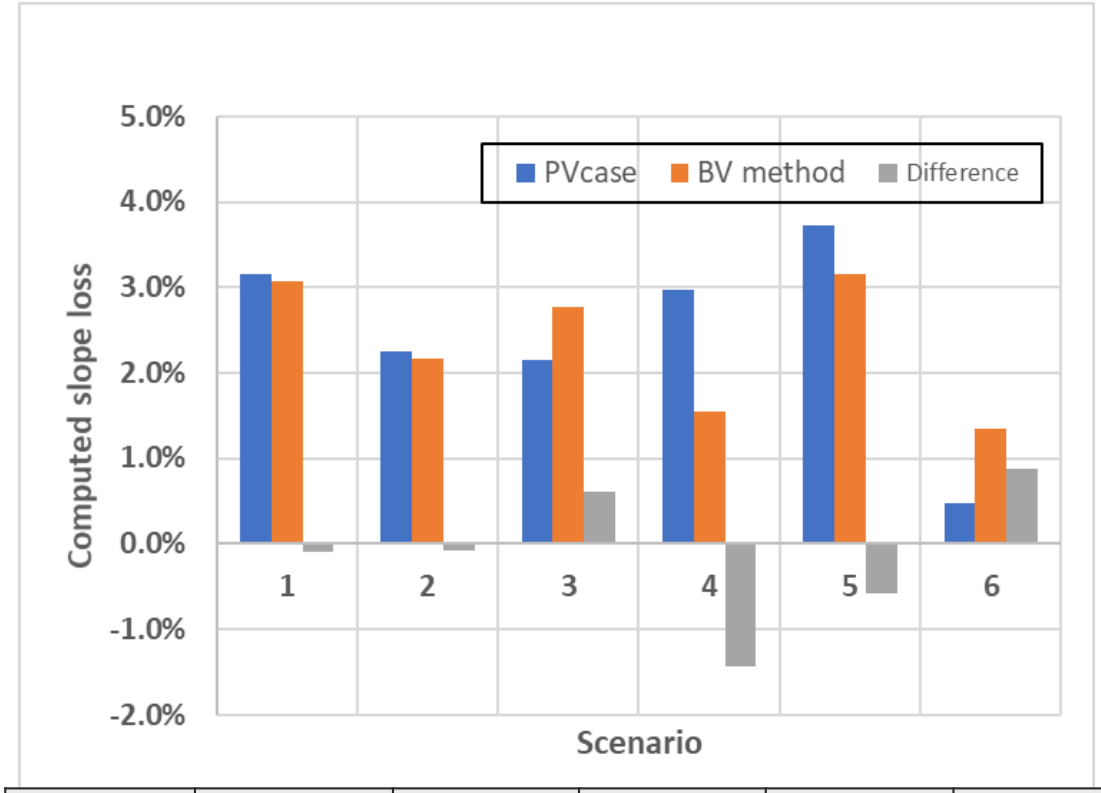
Modeling scenarios

Scenario	1	2	3	4	5
DC capacity	115 MW	76 MW	540 MW	78 MW	100 MW
Configuration	1P	2P	1P	2P	1P
GCR	37.2%	42.8%	38.5%	60.8%	37.2%
Pitch (m)	6.4 m	9.78 m	6.02 m	7.87 m	6.4 m
N slope (%)	0.93%	3.07%	4.39%	0.65%	0%
S slope (%)	0.64%	3.28%	3.29%	1.25%	0%
Net N-S slope (%)	0.50% N	0.01% N	0.22% S	0.53% S	0%
E slope (%)	1.72%	4.29%	0.71%	0.87%	5.0%
W slope (%)	2.05%	2.88%	0.92%	0.84%	5.0%
Avg E-W slope (%)	1.84%	3.15%	0.78%	0.86%	5.0%

*Scenario 6 same as scenario 1 but with thin film modules.

Results

Slope losses agree to within 1.5%.



-0.09%	-0.07%	0.61%	-1.44%	-0.57%	0.87%

Factors affecting slope loss

Terrain

Pitch/GCR

Latitude (sun angle)

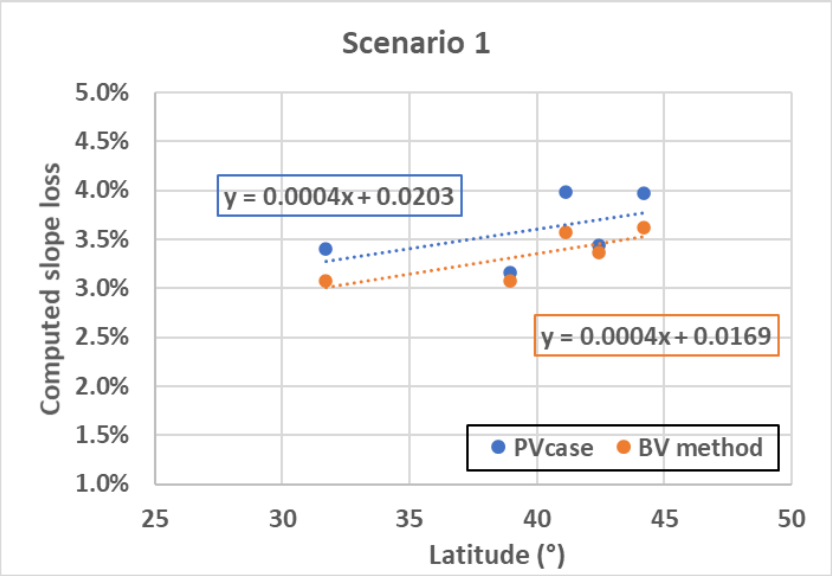
Weather (diffuse fraction)

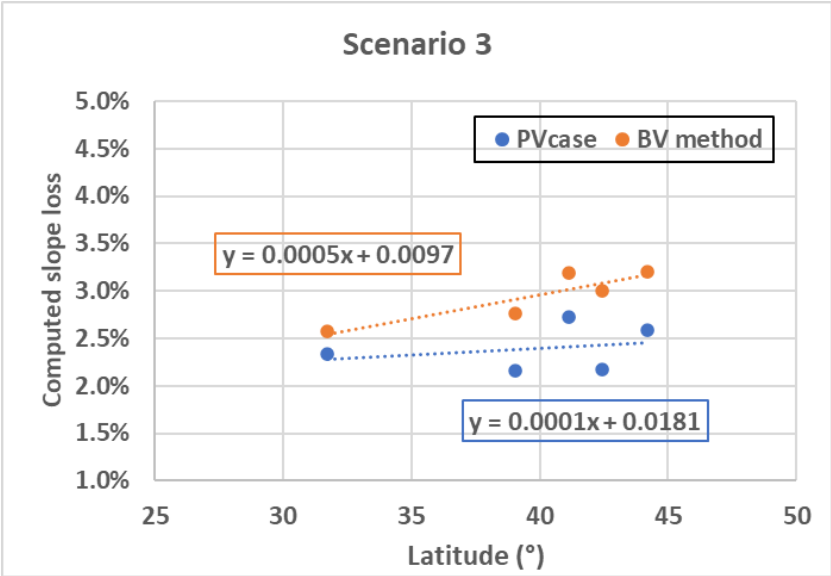
⟹ Analyze as a function of location and weather.

“Move” projects to multiple locations:

- South Dakota
- Michigan
- Nevada
- Virginia/Indiana
- Texas

Slope loss vs latitude

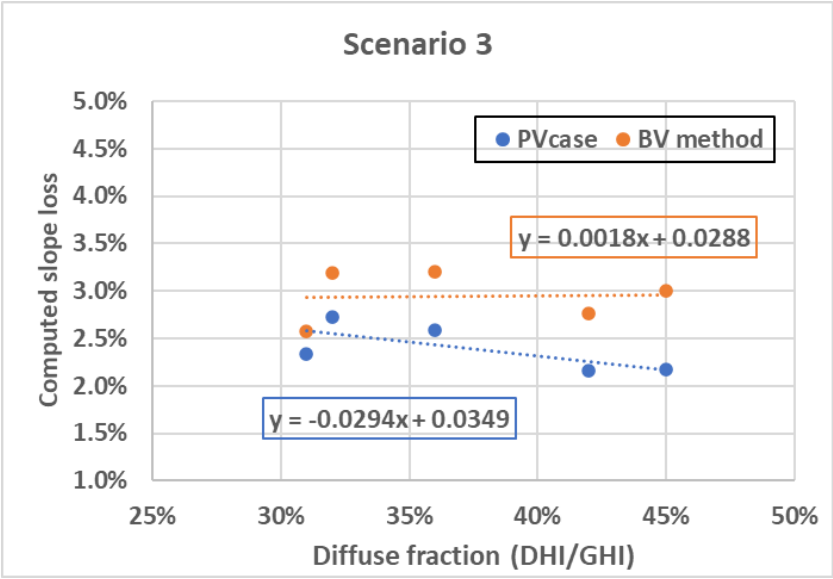


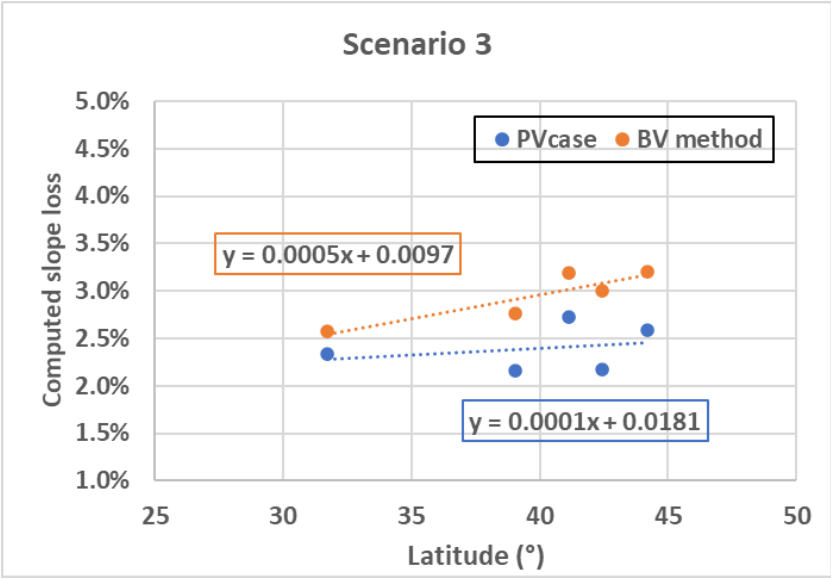


➡ Lower sun angle increases loss

➡ B&V method more sensitive to sun angle

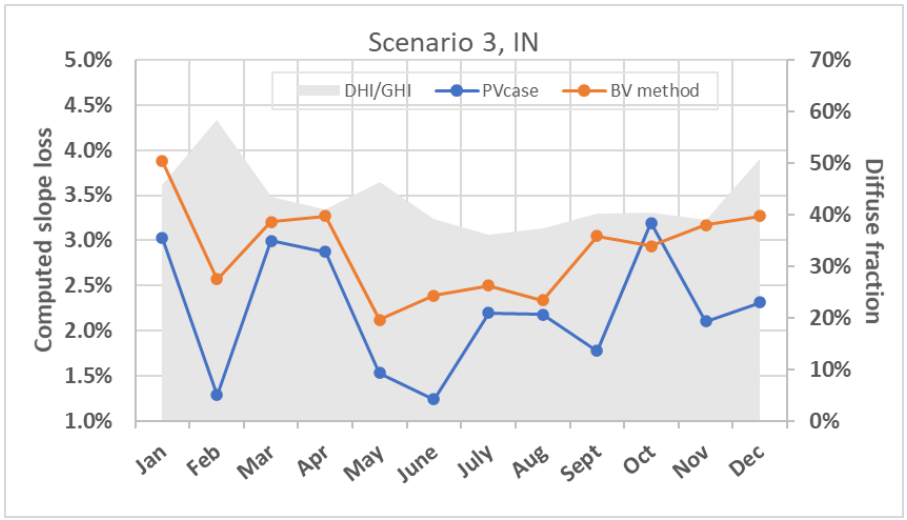
Slope loss vs diffuse irradiance fraction

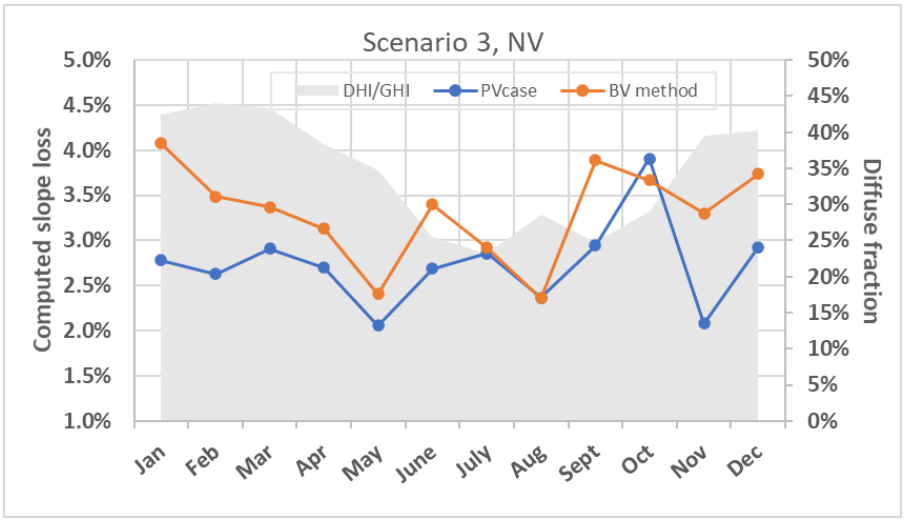




➡ No consistent trend in estimated slope loss vs. diffuse fraction.

Don’t forget about time! Seasonality effects





➞ Combination of low sun and cloudiness effects

Working with PVcase

Advantages

In common use for plant design

Easy to create complex, sloped scenes

Shading objects positioned at proper heights

Plays well with PVsyst

Results consistent with expectations

Disadvantages

Requires CAD software – performance teams may not have access

Creates many objects – can overwhelm PVsyst

Some limits in PVsyst's treatment of 3D scenes, particularly for back side production

Thank you for your attention!

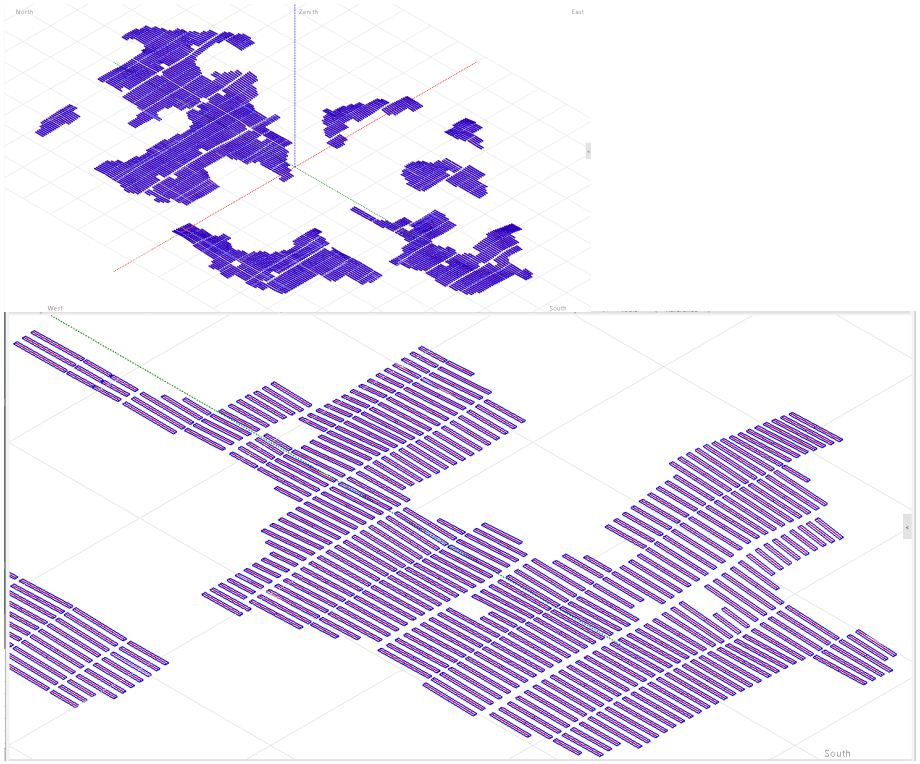
Contact Us

Building a World of Difference®
Laura Hinkelman, PV Performance Consultant
1 913 458 3493
HinkelmanL@bv.com

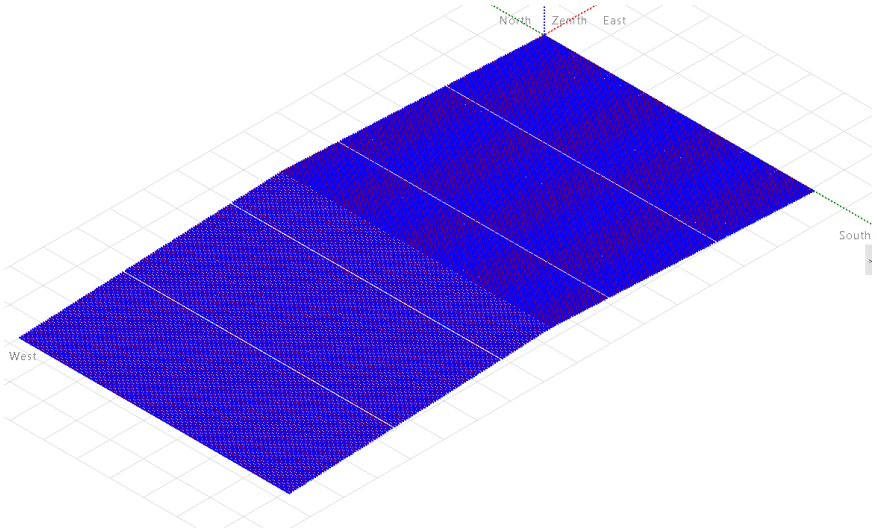
Discussion

Example scenes

Scenario 2



Scenario 5



Modeling results

Scenario	1	2	3	4	5	6*
DC capacity	115 MW	76 MW	540 MW	78 MW	100 MW	115 MW
Configuration	1P	2P	1P	2P	1P	1P
GCR	37.2%	42.8%	38.5%	60.8%	37.2%	37.2%
Pitch (m)	6.4 m	9.78 m	6.02 m	7.87 m	6.4 m	6.4 m
Net N-S slope	0.50% N	0.01% N	0.22% S	0.53% S	0%	0.50% N
Avg E-W slope	1.84%	3.15%	0.78%	0.86%	5.0%	1.84%
PVsyst slope loss	3.16%	2.24%	2.16%	2.98%	3.72%	0.48%
B&V slope loss	3.07%	2.17%	2.77%	1.54%	3.15%	1.35%
Difference	-0.09%	-0.07%	0.61%	-1.44%	-0.57%	0.87%

*Same as scenario 1 but with thin film modules.

Layout detail