Terrain Modeling for Utility-Scale PV

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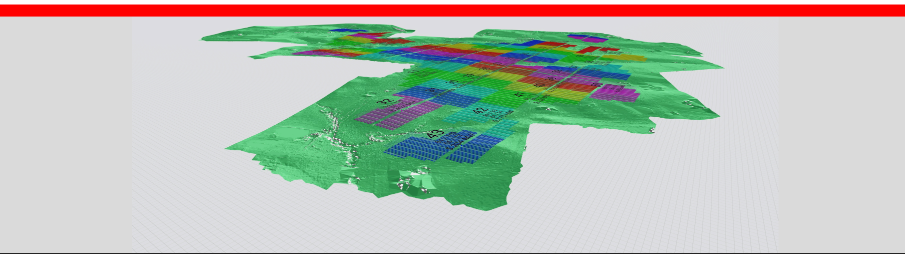
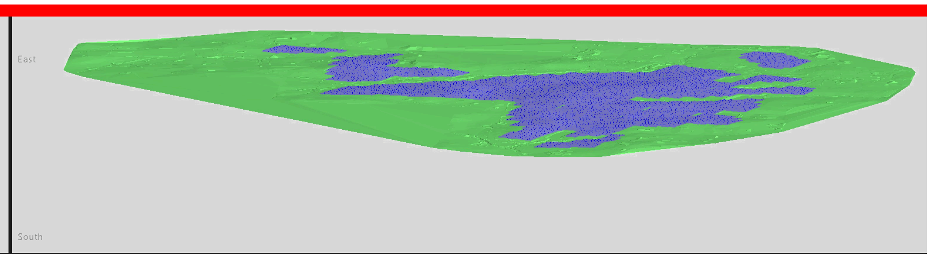


METHOD A (PVSYST + PVFARM TERRAIN)

Full-resolution DEM · terrain-matched tracker coordinates



METHOD B (PVSYST NATIVE TERRAIN)

Simplified terrain mesh · manual zone construction

1 BACKGROUND

Terrain variability drives orientation differences, horizon shading, and backtracking geometry across utility-scale PV sites. PVsyst's native terrain workflow requires engineers to simplify terrain meshes to meet file size limits, manually align layout in the shade scene, and hand-define zone boundaries — each step introducing operator-dependent error and significant time cost. PVFarm bypasses these constraints by exporting terrain-positioned tracker coordinates directly as a shade file, with no mesh simplification required.

METHOD A
PVsyst simulation — shade scene via PVFarm terrain import

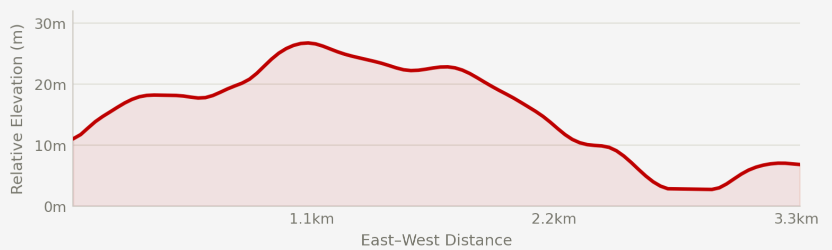
METHOD B
PVsyst simulation — shade scene built natively in PVsyst

Both methods produce a PVsyst hourly simulation. They differ only in how terrain is represented in the shade scene.

2 SITE TERRAIN PROFILE

East–west elevation cross-section from 62,956 pile coordinates.

EAST–WEST ELEVATION PROFILE (RELATIVE, METERS)



27 m — E–W VARIATION

3.3 km — SITE WIDTH

62,956 — PILE COORDS

Site-wide elevation range: 37.8 m

3 BUILD TIME — STEP BY STEP

METHOD A: 221 minutes total

METHOD B: 416 minutes total

■ Method A — PVsyst+PVFarm Terrain ■ Method B — PVsyst Native Terrain

	Method A	Method B
CAD & terrain preparation	12 min	7 min
Terrain export	93 min (bg)	48 min
Configure terrain CSV	— not required	55 min
Place on terrain / align	12 min	48 min
Import .SHD / zone creation	7 min	111 min
Simulation run	97 min	147 min

47% FASTER — 195 MINUTES SAVED
Zone creation (111 min) and terrain CSV configuration (55 min) entirely eliminated from Method A, which replaces manual alignment with a direct 12-minute terrain placement step.

4 METHODOLOGY

Both simulations used **identical inputs**: project boundary, 1P HSAT with backtracking, TMY weather file, electrical assumptions, soiling, and albedo. Single site-wide orientation. The only variable is how terrain is imported and operationalized in the shade scene.

DC CAPACITY	TRACKER	PVSYST	RESOLUTION
238 MWdc	1P HSAT backtracking	8.1 both runs	8760 hourly TMY

5 COGNITIVE LOAD — NASA TLX

Standardized operator workload scale

A standardized multi-dimensional scale for measuring operator workload across mental, physical, and emotional dimensions.

■ Method A (PVsyst+PVFarm Terrain) ■ Method B (PVsyst Native Terrain)

	Method A	Method B
Mental demand *(shorter = less load = better)*	2.3	4.85
Effort *(shorter = less load = better)*	2.1	4.33
Frustration *(shorter = less load = better)*	3.3	5.19
Performance / satisfaction *(longer = higher satisfaction)*	7.05	5.69

6 SIMULATION OUTPUTS — EQUIVALENT RESULTS

KEY FINDING
Annual E_Grid converges within **0.09%** and GlobInc within **0.003%**. Near-shading losses differ by only **0.04%**. The terrain method does not drive yield divergence at single-orientation resolution, but within this comparison it significantly changes how hard it is to get there.

■ Method A — PVsyst + PVFarm Terrain ■ Method B — PVsyst Native Terrain

	Method A	Method B	
Annual energy yield — E_Grid (GWh/yr)	482.9	483.3	Δ = −0.4 GWh | −0.09%
Plane-of-array irradiance — GlobInc (kWh/m²/yr)	2223.6	2223.5	Δ = +0.1 kWh/m² | +0.003%
Near-shading loss (% of GlobInc)	2.527%	2.489%	Δ = +0.04% · within expected variation for single-orientation geometry

7 CONCLUSIONS

A **Same answer, less work.** Both methods produce annual E_Grid within 0.09%. Method A gets there in 221 min vs. 416 min — 47% faster.

B **Lower cognitive load.** NASA TLX scores favor Method A on every dimension. The difficulty is built into Method B's process, not operator skill — and Method B is significantly less repeatable across operators.

C **Higher shade scene fidelity.** Method A imports full-resolution terrain-positioned tracker coordinates — no mesh simplification, no manual alignment, no zone construction.

D **Future work.** An orientation clustering pipeline under development (terrain OLS → Ward clustering → automated SHD export) is expected to unlock multi-orientation accuracy gains not captured in this single-orientation comparison.

LIMITATIONS
Single-operator trial — results reflect one engineer's experience running both workflows sequentially. Multi-operator validation and sites with greater terrain variability are recommended for future study.