Designer Validation Benchmark

Sun Safe LLC · Balcony Solar Designer, sunsafepv.com · Rutland, Vermont

v264
Tool revision tested
Run October 8, 2026
Baseline v207, October 7

Result. On identical weather, the Designer's yearly energy is within −3.8% to +2.5% of NREL's System Advisor Model (SAM) with no shade, and within 1.0% of SAM with the same traced shade. It reads low in 7 of 9 open-sky cases, the intended conservative bias. **Rerun on v264:** every figure matches v244 exactly, including Rutland (635 kWh) and the shaded cases. Des Moines and Phoenix still match the v207 baseline; the Rutland, VT case uses real NSRDB weather.

- Sales-style online calculators match PVWatts only for an ideal south-tilted panel. None ask about direction or shade, so for a vertical balcony panel they overstate by 29–81% facing south and 73–142% facing east.
- For a 1080 W kit in Rutland, simple payback ranges from 1.6 years (a sales-style default) to 3.0 years (PVWatts, ideal) to 3.8–5.6 years (vertical or shaded).

1. Open sky: Designer vs SAM vs PVWatts web yearly AC energy, kWh

Site	System (APsystems EZ1-LV, open rack)	Designer	SAM PVWatts v8	Designer vs SAM	PVWatts web	Designer vs web
Des Moines, IA	Test stand 2 × 255 W, 35° south	677	689	−1.8%	715	−5.4%
Des Moines, IA	Test stand, vertical south	465	479	−2.9%	498	−6.7%
Des Moines, IA	Test stand, vertical east	314	318	−1.3%	353	−11.1%
Des Moines, IA	1080 W kit (2 × 540 W), 30° south	1,470	1,457	+0.9%	1,511	−2.7%
Phoenix, AZ	Test stand 2 × 255 W, 35° south	879	908	−3.3%	903	−2.7%
Phoenix, AZ	Test stand, vertical south	542	564	−3.8%	552	−1.7%
Phoenix, AZ	Test stand, vertical east	454	459	−1.1%	450	+0.7%
Phoenix, AZ	1080 W kit (2 × 540 W), 30° south	1,933	1,929	+0.2%	1,920	+0.7%
Rutland, VT	Test stand 2 × 255 W, 35° south (new in v244)	635	620	+2.5%	618	+2.7%

- **Rutland (new):** NSRDB tmy-2020 for 43.61, −72.97, the hourly file PVWatts V8 itself returns, saved with the site on October 8, 2026. SAM run on the same file gives 1,215 kWh for 1 kW against PVWatts web's 1,210 (0.5%), which confirms the saved file.
- **Designer and SAM read the same weather file:** SAM's bundled NSRDB PSM v3 typical-year file for each city. PVWatts web used NSRDB tmy-2020 for the same coordinates, so its column also carries a weather-vintage difference (largest in Des Moines).
- **Shared inputs:** 14% system losses, 96% inverter efficiency, 900 W output limit, open-rack mounting, 0.2 ground reflectance.
- **Why the test stand reads lower:** the Designer uses the Suniva OPT255's own temperature coefficient (−0.42%/°C, NOCT 46 °C); PVWatts uses a generic −0.37%/°C. The Talesun 540 W in the kit beats the generic module, so the Designer reads slightly higher there.

2. With shade: Designer vs SAM, same skyline Des Moines, 510 W test stand

Skyline	Tilt	Designer shaded	SAM shaded	Difference	Designer shade loss	SAM shade loss
Simple solid skyline	35° south	504	509	−1.0%	25.5%	26.1%
Sun Safe ground-mount example	35° south	437	441	−1.0%	35.4%	36.0%
Simple solid skyline	Vertical south	293	293	+0.1%	36.9%	38.8%
Sun Safe ground-mount example	Vertical south	280	279	+0.4%	39.8%	41.7%

- **How SAM was given the shade:** the Designer's traced skyline (tree outlines counted as solid, as the Designer does) was exported as SAM's azimuth-by-altitude beam-shading table at 2° × 1°. SAM did its own sun tracking and interpolation.
- **One shared input:** SAM takes diffuse shade as a single percentage, so it was set from the Designer's sky view factor (Dozier & Frew 1990).
- **Both models drop the generic 3% shade allowance** inside the 14% losses once real shade is modeled (Dobos 2014). Shade loss is measured against each model's own open-sky result.

3. Sales-style calculators vs PVWatts Rutland, VT, 510 W test stand, kWh/yr

Tool	How it estimates	kWh/yr	vs PVWatts 35° S (619)	vs vertical S (463)	vs vertical E (347)
PES Supply ROI calculator	kW × 4.5 sun-hours default × 365; no losses	838	+35%	+81%	+142%
Voltflow, 4.5 sun-hours	kW × sun-hours × 82% × 365	687	+11%	+48%	+98%
Voltflow, 4.0 sun-hours	Same, Northeast midpoint	611	−1%	+32%	+76%
The Green Watt	PVWatts kWh per kW at its default (20° roof mount)	599	−3%	+29%	+73%

- **PVWatts reference** (web, NSRDB tmy-2020, 14% losses, 800 W output limit): 619 kWh at 35° south, 463 vertical south, 347 vertical east.
- **Figures come from each page's published formula and defaults**, not from typing into their forms. Voltflow's sun-hours are typed by the user; its page suggests 3.5–4.5 for the Northeast.
- **Not run:** Bright Saver's calculator (interactive page; its savings page says estimates "assume perfect conditions: direct sunlight all day, no shading, and ideal orientation and tilt") and SolarReviews (method not published; asks for a utility and monthly bill).
- **Boston University's 2026 plug-in solar study** used PVWatts with zero losses (DC = AC), which reads about 16% high against PVWatts' default 14% losses (1 ÷ 0.86).

4. Payback 1080 W kit, Rutland, VT

Tool or case	kWh/yr	Saved per year	Simple payback
PES Supply default (4.5 h, no losses, 30% credit)	1,774	$391.85	1.6 yr
Voltflow, 4.5 sun-hours	1,455	$321.32	2.7 yr
Voltflow, 4.0 sun-hours	1,293	$285.62	3.0 yr
PVWatts web, 30° south, open sky	1,301	$287.41	3.0 yr
The Green Watt (20° roof default)	1,269	$280.22	3.1 yr
PVWatts, 30° south, 20% shade	1,041	$229.93	3.8 yr
PVWatts, vertical south, open sky	939	$207.47	4.2 yr
PVWatts, 30° south, 30% shade	911	$201.19	4.3 yr
PVWatts, vertical east, open sky	703	$155.19	5.6 yr

- **Cost** $869.00 (US Solar Supplier kit price, racking not included). **Rate** $0.2209/kWh (Green Mountain Power, EIA). Payback = cost ÷ first-year savings (SAM simple payback); no rate increases or panel aging.
- **The 30% credit** is PES Supply's default (federal Residential Clean Energy Credit, Section 25D). The Green Watt reports that credit ended January 1, 2026; confirm before relying on it.
- **The 20% and 30% shade rows** apply the 20–30% shade loss measured at the Sun Safe test stand in September 2026 to the PVWatts result. They show the range; they are not a traced run.

5. Method and how to rerun

Designer. Revision v264 (baseline v207; previous rerun v244), run headless in Chromium. Location set by coordinates; the typical-year weather the Designer normally fetches from PVWatts V8 (timeframe=hourly: beam, diffuse, air temperature) was served from SAM's bundled file for the same city. Yearly AC energy read from the Designer's own result.

SAM. PVWatts v8 module of NREL's open-source SAM simulation core (ssc release 2025.4.16), compiled from source and called through its C API. Inputs: system size, DC/AC ratio (900 W limit), 96% inverter, 14% losses, open rack, tilt, azimuth, albedo 0.2.

PVWatts web. NREL PVWatts V8 API (developer.nlr.gov), dataset nsrdb, module type standard, same inputs.

Weather files. SAM repository, deploy/solar_resource: des_moines_ia_41.586835_-93.624959_psmv3_60_tmy.csv and phoenix_az_33.450495_-111.983688_psmv3_60_tmy.csv.

Rerun. The same cases are rerun against each new Designer revision; results are reported against the v207 baseline. October 8, 2026, revision v244: identical open-sky results, shaded results within 0.3 kWh; Rutland added. October 8, 2026, revision v264: all results identical to v244 (the changes since then are checks, labels and reports, not the energy model).

6. Limits

- SAM here means SAM's PVWatts v8 model. SAM's detailed module-by-module model was not run.
- **Rutland reads high (+2.5%) because of wind.** Rutland's NSRDB file averages 0.23 m/s (half the hours calm), so SAM's cell-temperature model runs the panels hotter. The Designer's NOCT method assumes about 1 m/s. With 1 m/s in the file, SAM gives 633 kWh, within 0.3% of the Designer. At very calm sites the Designer is therefore slightly optimistic; a wind adjustment is under review to keep it conservative.
- The shade comparison checks the energy math, not the photo-to-skyline step. That needs a field reading (for example, a Solar Pathfinder) at the same spot.
- PVGIS (European Commission) was not run: its site blocks automated requests.

Sources

- NREL PVWatts V8 API: https://developer.nlr.gov/docs/solar/pvwatts/v8/
- NREL SAM simulation core (ssc): https://github.com/NREL/ssc · SAM weather files: https://github.com/NREL/SAM/tree/develop/deploy/solar_resource
- Dobos, A. P. (2014). PVWatts Version 5 Manual. NREL/TP-6A20-62641.
- Dozier, J., & Frew, J. (1990). Rapid calculation of terrain parameters for radiation modeling from digital elevation data. IEEE Trans. Geosci. Remote Sens. 28(5).
- PES Supply ROI calculator: https://www.portlandiaelectric.supply/pages/solar-panel-roi-calculator
- Voltflow balcony solar calculator: https://www.voltflow.net/balcony-solar-calculator
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- Boston University, Plug-in Solar Offsets and Savings (2026): https://www.bu.edu/eci/files/2026/05/Plug-in-Solar-Offsets-Savings-4-30-26c.pdf