Improving TMY Solar Resource Selection with an Maximum Likelihood Estimation (MLE)-Based Plane-of-Array (POA) Approach

Better irradiance assumptions don't just improve models — they improve deals.

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Motivation & Problem Statement

- Long-term solar resource estimates drive design, financing, and operation of PV plants.
- **Current method :**
  - Projects rely on multiple resource datasets (satellite, ground-tuned, modeled, hybrid) with non-overlapping periods and differing uncertainties.
  - Traditional selection methods use simple averages, medians, or "favorite vendor" choices that ignore uncertainty and correlation between datasets.
- **Outcome**: biased or inaccurate long-term resource estimates and mispriced project risk.
- A seemingly small 1–2% bias in resource selection can materially shift financing outcomes.

Why POA-Based MLE?

- POA irradiance is measured on the actual tilted module plane, directly tied to PV output including array tilt, orientation, and albedo.
- GHI ≠ energy: it hides tilt, diffuse behavior, and array geometry; two datasets with similar GHI can diverge materially at POA.
- Traditional focus on satellite-derived GHI and simple aggregates can under- or over-estimate long-term resource, impacting P50/P90 and terms.
- **Key technical shift**: Moving MLE from GHI to POA makes the likelihood physically meaningful.

Role of Diffuse Fraction (DF)

- POA includes direct, diffuse, and ground-reflected components; diffuse treatment strongly influences POA for trackers and tilted arrays.
- Different data sources have different diffuse profiles, producing non-trivial differences in POA even when GHI agrees.
- Review of diffuse fraction (DF) for each dataset is mandatory, not optional.
- DF-based factors can refine TMY diffuse profiles, improving consistency across datasets.

MLE + DF Workflow

Objective: Select the most probable long-term POA resource, constrained by physics and data — not by curve fitting.

Step 1: Compare DF across datasets to identify systematic differences and potential biases.

Step 2: Where justified, adjust DF using timeseries or measured data, refining TMY diffuse behavior.

Step 3: Compute POA for each candidate dataset and derive its diffuse fraction (DF) profile.

Step 4: Maximum Likelihood Selection — choose the candidate dataset whose DF-adjusted POA value is closest to the MLE POA.

Step 5: Apply a small MLE factor if needed to align final POA with the composite likelihood outcome.

Utility-Scale Case Study

- 100 MWac / 130 MWdc utility-scale PV plant with single-axis tracking, located in the U.S. Southwest.
- Long-term fixed-price PPA, financed using P90-based debt sculpting.
- Five independent solar resource datasets, including satellite-derived TMY products and a ground-tuned hybrid dataset.
- Datasets show modest agreement at GHI, but larger divergence at POA.
- Two approaches compared: Traditional GHI-based selection vs. POA-based MLE framework with explicit DF review.

Energy Yield Impacts

~1%	20–30%	2.5–3%
P50 Net Energy Shift from DF-adjusted MLE POA selection	Spread Reduction via MLE Weighting at POA	P90/P50 Net Energy Increase from Uncertainty Reduction

Debt Service Coverage Ratio (DSCR) & Credit Implications

- Under a traditional GHI-based approach, the project achieves P90 DSCR ≈ 1.30x.
- With POA-based MLE + DF review, P90 DSCR improves to ~1.36x–1.38x, a 0.06x–0.08x increase.
- This higher DSCR provides more covenant headroom and lowers risk of DSCR breaches in low-resource years.
- May allow lenders to reduce structural mitigants (e.g., debt service reserves, cash sweep triggers).
- Benefits achieved without changes to capex, O&M, or contracts — purely from more accurate, uncertainty-aware resource modeling.

Stakeholder Takeaways

- **Developers**: POA-based MLE improves financing outcomes without increasing development risk. Enables more efficient capital structures.
- **Lenders**: Greater transparency into how resource uncertainty is quantified and reduced. Better alignment between technical diligence and credit risk.
- **Tax Equity & Investors**: Tighter downside distributions improve confidence in long-term cash flow stability.
- Enhanced physics + statistics → improved financial resilience and more bankable projects at utility scale.

Core Message

POA-based MLE with explicit diffuse fraction review transforms TMY resource selection from a heuristic choice into a physics-grounded, uncertainty-aware process — narrowing P90/P50 bands, strengthening DSCR, and directly supporting more durable, financeable solar deals.

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