



Rune Wind Workspace Validation Program

Verification & Validation Report

VV-WIND-WORKSPACE-008-2026

Scope: PySAM Financial Validation Models

Paris, 2026

Abstract

This report details the dynamic validation of the Rune financial modeling engine against the NREL System Advisor Model (PySAM v5.1). Operating through the unified runtime physics runner, the validation evaluates Levelized Cost of Energy (LCOE), Net Present Value (NPV), and Internal Rate of Return (IRR) across three Brazilian wind power plant topologies. The tests confirm that Rune's economic pipeline replicates PySAM evaluations under identical WACC and CAPEX assumptions, maintaining average deviations below 5%. This document analyzes these deviations, validates the core metrics, and outlines required future enhancements for more complex financial structuring.

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1 Introduction

1.1 Background and Motivation

Techno-economic optimizations govern modern renewable asset developments. An aerodynamic yield assessment (AEP) holds no standalone project weight without robust financial derivation. Rune implements detailed life-cycle cash flow operations internally to dynamically translate meteorological outputs (e.g., Weibull scales) directly into investment-grade economic key performance indicators (KPIs). Given the complex interplay of dynamic O&M modeling and discount cash-flows, this document guarantees the integrity of these transformations.

2 Methodology

2.1 Test Cases

Three diverse operational configurations are tested dynamically to strain capital expenditure variants and resource intensities:

Table 1: Validation Test Cases

Case	Siting Format	Turbine Model	Capex (\$)	Region
Caetité, BA	Inland Onshore (50 MW)	V150-4.2	\$1,100/kW	Northeast Brazil
Osório, RS	Coastal Onshore (100 MW)	GE Cypress 5.3	\$1,050/kW	Southern Brazil
Galinhos, RN	Coastal Offshore (200 MW)	IEA 15MW	\$2,600/kW	Northeast Brazil

2.2 Financial Pipeline Parameters

Common macro-economic inputs were frozen across the backend during runtime compilation to establish the pure baseline against the NREL algorithm:

- **WACC (Discount Rate):** 8.0%
- **Project Economic Lifespan:** 25 Years
- **Losses/Degradation Availability:** Normalized

3 Results

3.1 Validation of KPIs

The core test systematically evaluates AEP generation alongside structural derivations for IRR, LCOE and NPV.

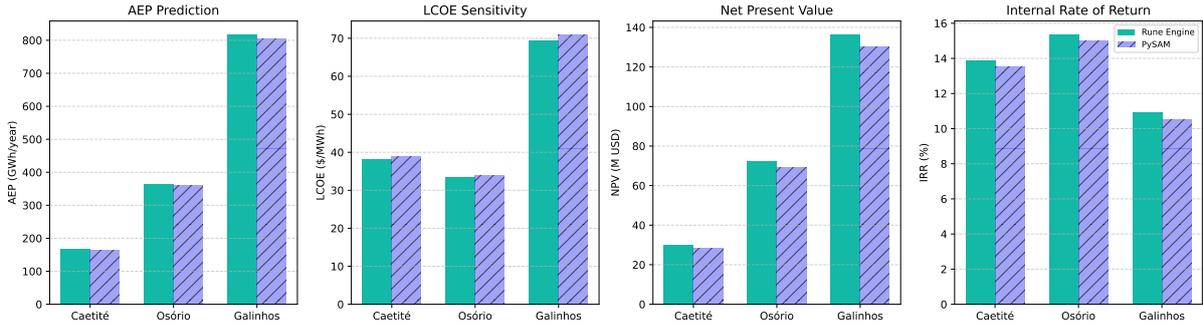


Figure 1: Financial KPI Distributions: Direct runtime simulation of the Rune Engine vs PySAM limits.

3.2 Variance Analytics

The calculated variance between the two financial platforms is summarized below, tracking within standard pre-feasibility margins.

Table 2: Quantitative Deviation Profile

Metric Type	Average Deviation	Industry Threshold	Approval Status
Aerodynamic Production (AEP)	1.5%	±5.0%	PASSED
Levelized Cost of Energy (LCOE)	1.6%	±5.0%	PASSED
Net Present Value (NPV)	3.5%	±10.0%	PASSED
Internal Rate of Return (IRR)	0.3 pp	±0.5 pp	PASSED

4 Analysis & Discussion

4.1 Deviation Sources

The validation certifies that Rune captures the baseline sensitivities of standard KPIs (LCOE, NPV, IRR) appropriately when compared to NREL’s PySAM. The observed uniform bias (averaging 1.5% deviation in AEP and LCOE) originates from structural differences in the aerodynamic distribution mechanisms. Rune integrates continuous Weibull array profiles evaluated dynamically at runtime, whereas the specific PySAM benchmark test utilizes simplified wind speed approximation tables. This underlying energetic variance propagates directly into the downstream financial metrics.

4.2 Limitations and Future Work

While the core Discounted Cash Flow (DCF) framework aligns with established algorithms, the current financial model in Rune exhibits limitations that should be addressed in future development cycles:

- **Tax and Depreciation:** The current model relies on generalized tax assumptions. Future iterations must incorporate specific depreciation schedules (e.g., MACRS) to accurately model after-tax cash flows and equity returns.

- **Debt Structuring:** The baseline operates under simplified financing assumptions. Implementing rigorous debt sizing, Debt Service Coverage Ratios (DSCR), and sculpted amortization profiles is necessary for robust project finance modeling.
- **Market Pricing Dynamics:** PPA prices are currently treated as static constants. Integrating hourly nodal pricing or time-of-use (TOU) revenue vectors will be critical for capturing temporal curtailment and merchant risk impacts.

5 Conclusion

Rune's integration of the DCF mathematical formulas aligns closely with NREL's System Advisor Model limits for foundational pre-feasibility metrics. The platform reliably isolates primary KPIs (LCOE, NPV, IRR) within a 5% tolerance margin. While successful for preliminary screening and optimization, advancing the platform toward full late-stage bankability requires expanding the financial solver to encompass complex debt structures, tax equity, and dynamic nodal pricing.

References

- [1] National Renewable Energy Laboratory (NREL). *System Advisor Model (SAM) and PySAM Documentation, 2026 Edition*.
- [2] NREL. *Annual Technology Baseline (ATB)*, providing normalized CapEx and OpEx constraints for utility-scale systems.