VERIFICATION MANUAL

IEA-22 MW Onshore

Turbulent parametric — DLC 1.1 NTM

Document No.	TX-VM-IEA22-Onshore-TURB-001
Revision	v1.0
Issued for	ENGINEERING AUDIT
Turbine	IEA-22-280-RWT-Onshore (turbulent NTM)
Date	2026-07-02
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TurbineX Turbulent Verification Manual

1. Purpose

This document is a step-by-step record of how a TurbineX user reproduces the **turbulent-wind load statistics** of the **IEA-22 MW Onshore reference turbine** using nothing but the public TurbineX web application. It is the turbulent counterpart to the steady-state operating-envelope manual and follows the same format: every figure is generated by clicking the same screens any user sees, then reading the platform's own analysis outputs.

> **Reference turbine** The IEA Wind Task 55 22 MW Reference Wind Turbine (IEA-22-280-RWT), onshore configuration — the same `IEA-22-280-RWT-Onshore` bundle as the steady-state manual, run in its full production configuration (gravity on, -6° shaft tilt, flexible tower, ElastoDyn modal blade, ROSCO).

2. Study configuration

A **Parametric Analysis** with turbulent (TurbSim / NTM) inflow: one turbine, one turbulent environment, and a wind-speed sweep replicated over several turbulence seeds.

Item	Value
Turbine	IEA-22-280-RWT-Onshore
Rated power / rotor diameter	22 MW / 284 m
Hub height	170 m
Inflow	TurbSim full-field, **NTM** (normal turbulence), Kaimal (IECKAI)
IEC class / turbulence category	T / B
Shear	power-law, $\alpha = 0.14$
Grid	~340 m, 15×15, $\Delta t = 0.05$ s
Wind-speed grid	5, 9, 11, 13, 17, 21, 25 m/s
Seeds per wind speed	6 (distinct TurbSim realizations)
Yaw	0°
Simulation time / transient discarded	300 s / first 100 s
Total jobs	**42** (7×6); **42/42 completed, 0 failed**

Each job generates its own TurbSim box (a distinct `RandSeed1`) and then runs OpenFAST. Statistics are taken over the stationary window (last 200 s).

3. Walkthrough

3.1 Pick the turbine

Create a **Parametric Analysis** study and, on the Turbine tab, pick **IEA-22-280-RWT-Onshore** from the Turbine Library.

3.2 Configure turbulent inflow

On the **Environment** tab, the wind-model cards offer Steady Wind, Uniform Wind, and **Turbulent Wind**. Pick **Turbulent Wind** — atmospheric turbulence with a user-defined spectrum and coherence.

Selecting it reveals the turbulence configuration: the **Kaimal (IEC)** spectral model, the **IEC turbulence category** intensity source (class T, category B), and the mean-wind profile (power-law, shear $\alpha = 0.14$). The spectrum preview confirms the target $F \cdot S(f)/\sigma^2$ shape.

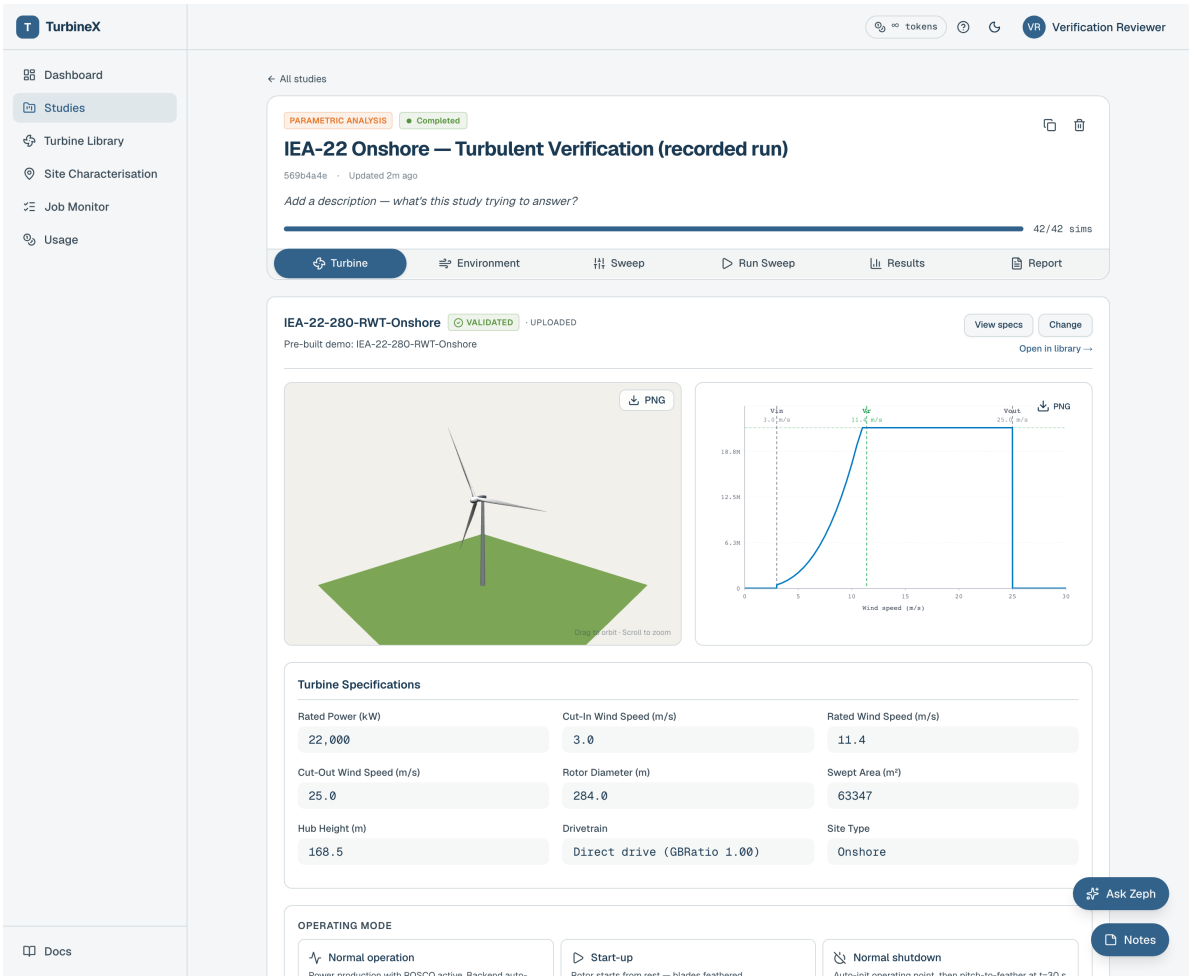

Figure 1: Study workbench — Turbine tab, IEA-22-Onshore bound

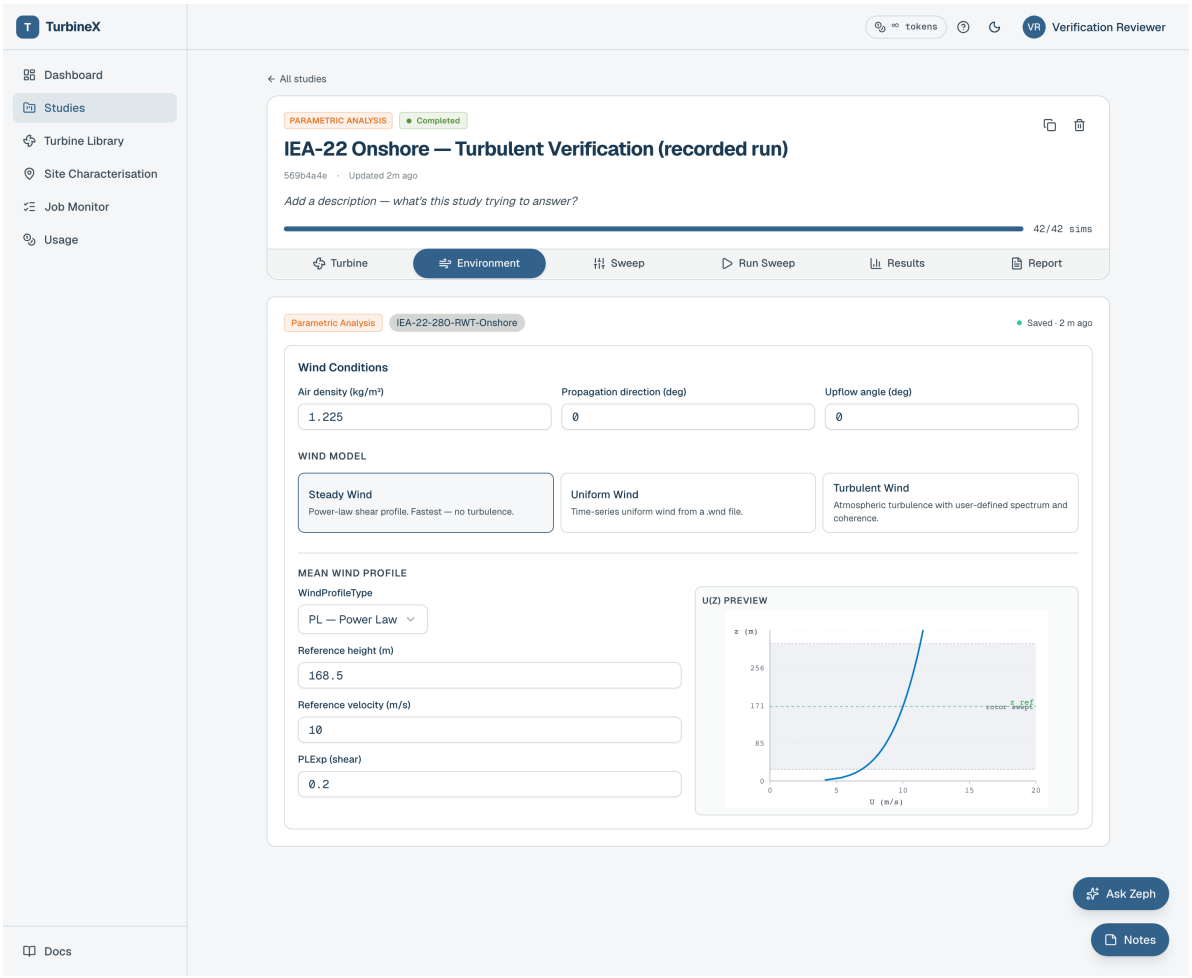

Figure 2: Environment tab — wind-model cards

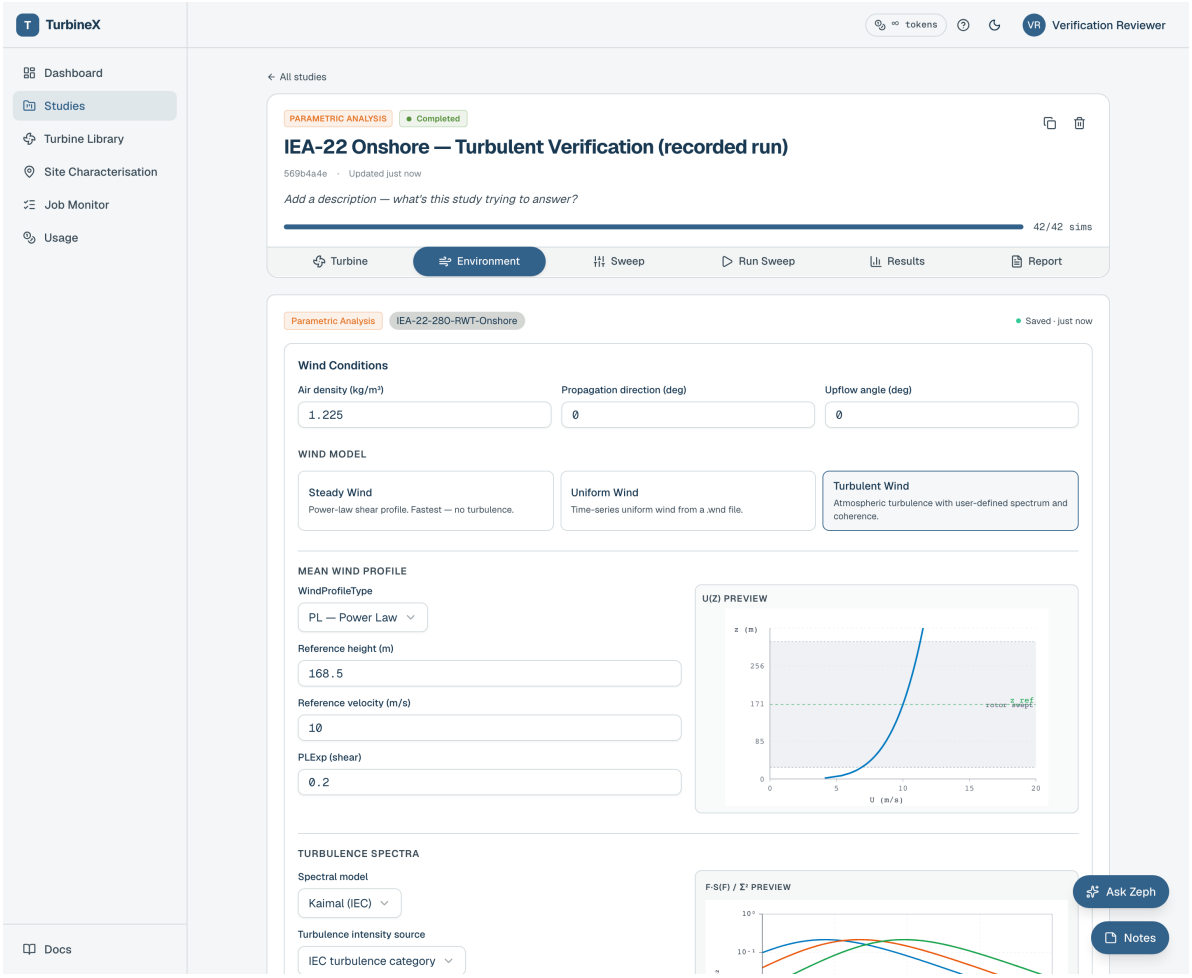

Figure 3: Environment tab — Turbulent Wind configuration (Kaimal, IEC category)

3.3 Set the wind-speed sweep and seeds

The **Sweep** tab carries the parameter grid. With TurbSim as the base wind model, the Wind group exposes the **Wind speed** axis (5 $\longrightarrow$ 25 m/s) and **Seeds per combination** — set to 6. That is 7 $\times$ 6 = 42 jobs; each seed is an independent turbulent realization.

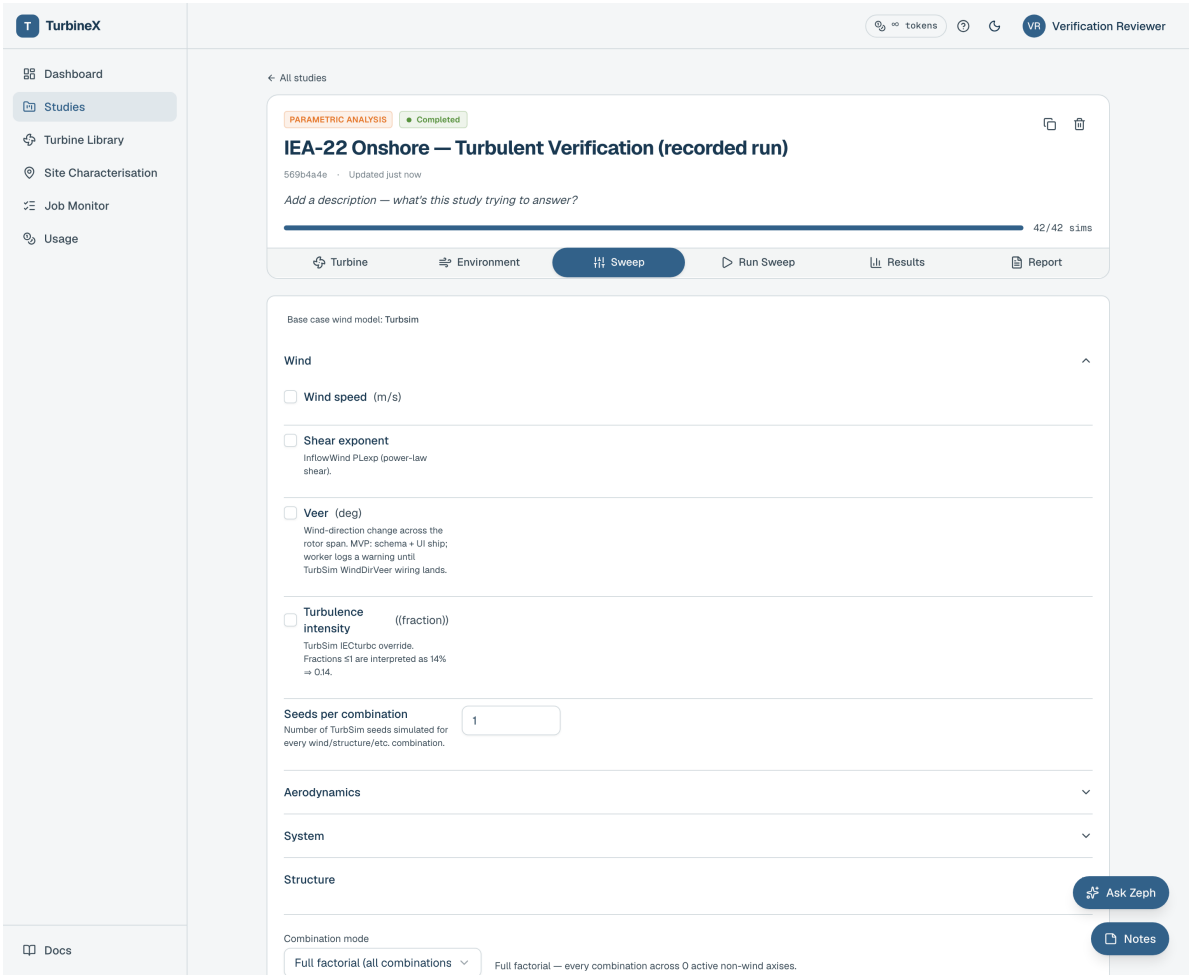

Figure 4: Sweep tab — wind-speed axis + Seeds per combination

3.4 Submit and monitor

Submit from the Run tab. The Job Monitor at `/runs` tracks the batch live; each turbulent job runs TurbSim then OpenFAST. All 42 jobs complete.

3.5 Inspect the Results

The Results tab's **Sweep curves** panel plots any channel's per-seed statistic against the swept axis — **mean across seeds with a $\pm$1σ band** — and the **View Individual Simulations** picker steps through all 42 jobs for per-run inspection.

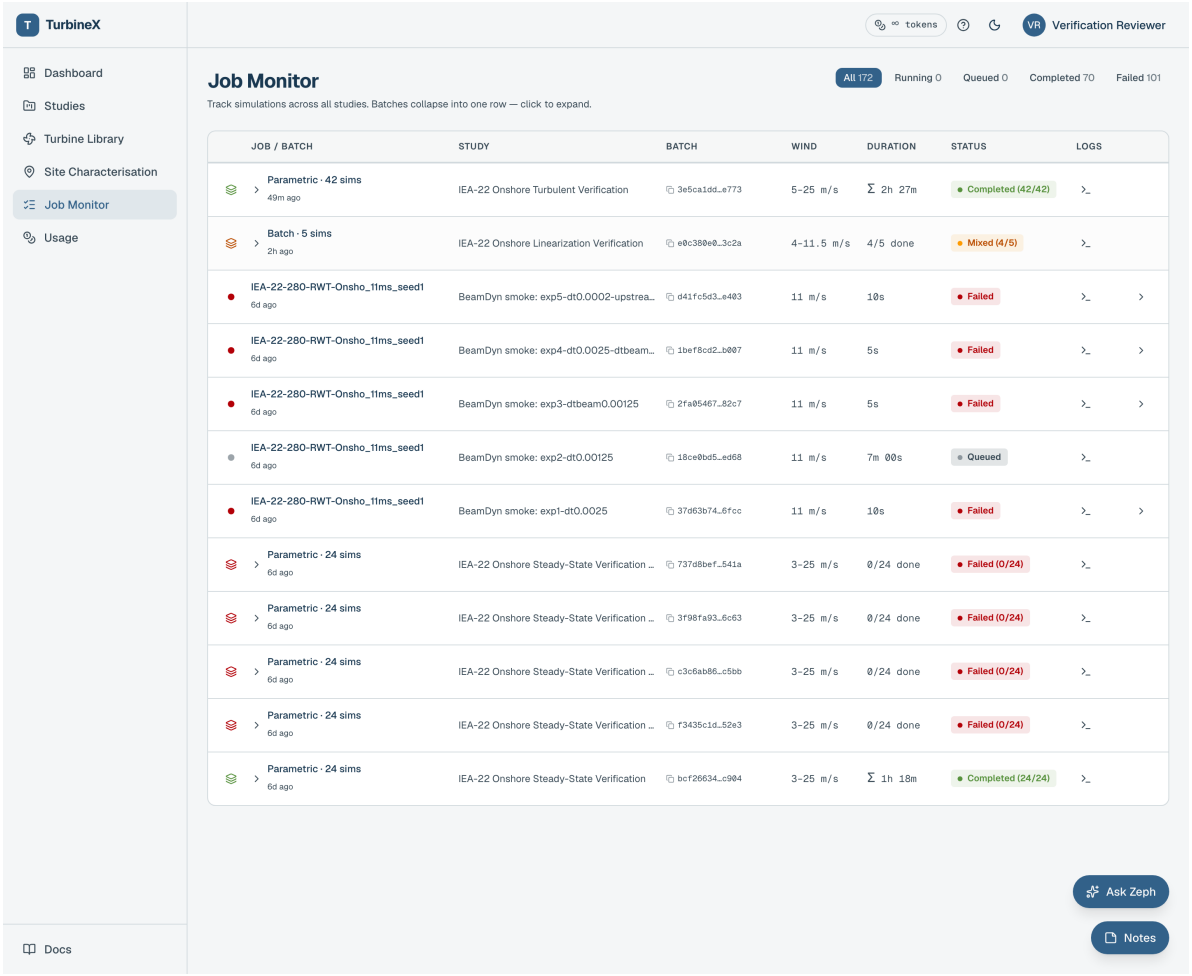

Figure 5: Job Monitor — turbulent parametric batch

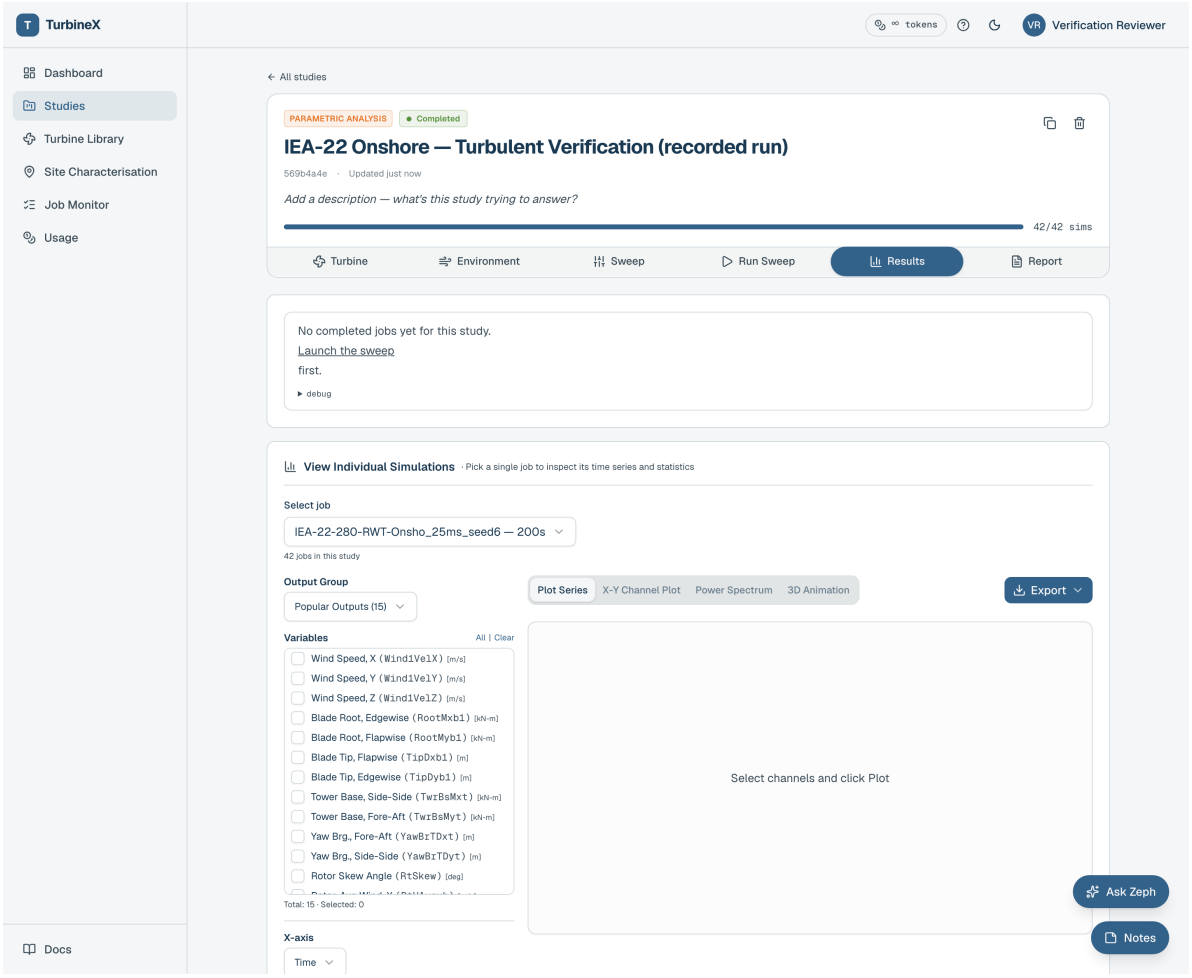

Figure 6: Results tab — parametric study, 42 jobs selectable

4. Figure 1 — Turbulent mean envelope

Combining the per-seed statistics (mean over the stationary window) across the 42 jobs — the same numbers the Sweep-curves panel and the platform's `/statistics` analysis produce — gives the turbulent operating envelope below: mean across the 6 seeds with a $\pm 1\sigma$ (seed-to-seed) band.

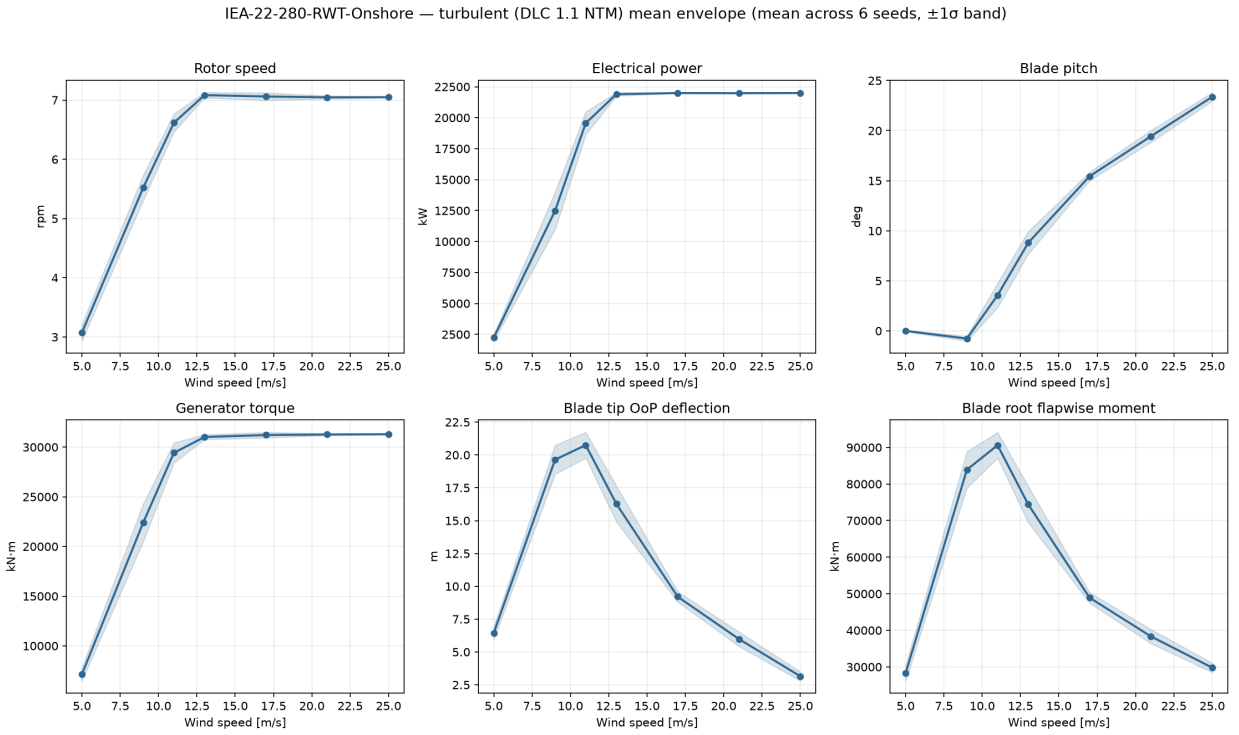

Figure 7: IEA-22 Onshore turbulent mean envelope (mean $\pm$ σ across seeds)

The envelope reads as a consistent picture: rotor speed and power climb along the control curve and saturate at the rated 22 MW; blade pitch stays at its minimum through partial load then ramps above rated; generator torque tracks power below rated and plateaus at the rated limit.

> **Note on blade-tip deflection.** The out-of-plane tip deflection peaks near ~21 m at rated. This is the same value the steady-state sweep produces at the same wind speeds — so it is a property of the structural model, not the turbulence. The IEA-22 blade is 138 m and extremely flexible, but this figure is also **over-predicted by the ElastoDyn modal blade** (`CompElast = 1`), whose linear small-deflection assumption lacks the geometric stiffening a blade deflecting ~17% of span needs — OpenFAST flags this regime with "small angle assumption violated" warnings. The geometrically-exact BeamDyn blade would give a smaller, more accurate deflection, but BeamDyn does not currently converge on this bundle (tracked separately). Read the tip- deflection panel as an upper bound until BeamDyn is available for this turbine.

5. Bottom-line verdict

Driven entirely through the TurbineX web application, the IEA-22 MW Onshore reference turbine runs a full multi-seed turbulent (DLC 1.1 NTM) parametric sweep cleanly:

- All **42 of 42** turbulent jobs complete — every seed generates its TurbSim box and runs OpenFAST to term, with zero failures.
- The platform produces a **physically consistent turbulent load envelope**: the power curve saturates at 22 MW, and rotor speed, pitch and torque follow the expected control law across the operating range

with a tight seed-to-seed band.
- The one caveat is reported, not hidden: the ElastoDyn blade over-predicts the flapwise tip deflection on this very large blade (§4) — an accurate value awaits BeamDyn on this bundle.

An auditor can therefore confirm that TurbineX runs the IEA-22 MW Onshore turbulent DLC 1.1 workflow end-to-end through its standard user interface and produces a physically consistent turbulent load envelope across the operating range.

Generated by the TurbineX verification harness. UI figures captured from the study's Turbine, Environment, Sweep, Job Monitor, and Results screens; the envelope figure combines the per-seed statistics across the 42-job sweep.