Wind Energy from a Weibull Wind Distribution

Annual energy and capacity factor of a wind turbine from mean wind speed corrected to hub height, a Weibull shape factor and a simple power curve.

Input parameters

Unit system: SI

Parameter	Value	Unit
Mean wind speed at the reference height	6.0000	m/s
Reference height	10.000	m
Hub height	100.00	m
Shear exponent	0.14000	
Weibull shape factor	2.0000	
Rated power	2,000.0	kW
Cut-in speed	3.0000	m/s
Rated speed	12.000	m/s
Cut-out speed	25.000	m/s
Availability and other losses	10.000	%

Calculated results

Parameter	Value	Unit
Mean speed at hub height	8.2823	m/s
Weibull scale at hub height	9.3456	m/s
Mean wind power density	664.60	W/m²
Capacity factor	36.018	%
Annual energy	6,314.7	MWh

Notes for this case

• Simplified power curve: cubic between cut-in and rated speed, rated output to cut-out. Use the maker's power curve for a bankable estimate. Weibull k ≈ 2 (Rayleigh) for most inland sites; air density 1.225 kg/m³.

Formula and method

$$\bar{v}_h = \bar{v}_r \left(\frac{z_h}{z_r}\right)^{\alpha}, \quad c = \frac{\bar{v}_h}{\Gamma(1+1/k)}, \quad CF = (1-f_l)\int P(v) f(v)\, dv / P_r, \quad E = CF P_r t_a, \quad \frac{P}{A} = \frac{1}{2}\rho_0 c^3 \Gamma\left(1+\frac{3}{k}\right)$$

Variables

$\bar{v}_r$	Mean wind speed at the reference height	m/s
z_r	Reference height	m
z_h	Hub height	m
α	Shear exponent	-
k	Weibull shape factor	-
P_r	Rated power	W
v_{in}	Cut-in speed	m/s
v_r	Rated speed	m/s
v_{out}	Cut-out speed	m/s
f_l	Availability and other losses	-
$\bar{v}_h$	Mean speed at hub height	m/s

c	Weibull scale at hub height	m/s
P/A	Mean wind power density	W/m²
CF	Capacity factor	-
E	Annual energy	J
t_a	One year, 365.25 days (8 766 h)	s
ρ_0	Air density, fixed at 1.225 kg/m³	kg/m³

Method and standards

Weibull integration.

Assumptions and limits

- The year is 365.25 days (8 766 h), allowing for leap years; calculators that use 8 760 h give energy about 0.07 % lower.
- The power density uses a fixed air density of 1.225 kg/m³ (sea level, 15 °C); scale it by the site density for altitude or temperature. The capacity factor comes from the normalised power curve and does not depend on density.
- Weibull distribution; simplified power curve.

Report details

Report reference	FCC-NKSS-Q5H3 (the same inputs always give the same reference)
Generated	23 November 2026, 17:34 UTC
Calculator	Wind Energy from a Weibull Wind Distribution
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	2 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/environmental/wind-power/wind-energy-weibull

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.