Weibull Wind Parameters from Mean and Standard Deviation

Weibull shape and scale factors from the mean and standard deviation of wind speed, the energy pattern factor, mean wind power density and time above a speed.

Input parameters

Unit system: SI

Parameter	Value	Unit
Mean wind speed	10.000	m/s
Standard deviation of wind speed	5.0000	m/s
Air density	1.2250	kg/m³
Wind speed of interest (for time above it)	12.000	m/s

Calculated results

Parameter	Value	Unit
Weibull shape factor	2.1013	
Weibull scale factor	11.291	m/s
Energy pattern factor	1.8208	
Mean wind power density	1,115.2	W/m²
Power density from the mean speed alone	612.50	W/m²
Fraction of time above U_x	32.091	%
Standard deviation of a Rayleigh distribution with the same mean	5.2272	m/s

Notes for this case

• k and c solve Ū = cΓ(1 + 1/k) and σ²/Ū² = Γ(1 + 2/k)/Γ²(1 + 1/k) − 1 together. k = 2 is the Rayleigh distribution. Two sites with the same mean speed can differ greatly in power because the power goes with the mean of U³.

Formula and method

$$\bar{U} = c\Gamma\left(1+\frac{1}{k}\right), \quad \frac{\sigma^2}{\bar{U}^2} = \frac{\Gamma(1+2/k)}{\Gamma^2(1+1/k)} - 1$$

$$K_e = \frac{\Gamma(1+3/k)}{\Gamma^3(1+1/k)}, \quad \frac{P}{A} = \frac{\rho c^3}{2}\Gamma\left(1+\frac{3}{k}\right), \quad 1 - F(U) = e^{-(U/c)^k}$$

Variables

$\bar{U}$	Mean wind speed	m/s
σ	Standard deviation of wind speed	m/s
ρ	Air density	kg/m³
U_x	Wind speed of interest (for time above it)	m/s
k	Weibull shape factor	-
c	Weibull scale factor	m/s
K_e	Energy pattern factor	-
P/A	Mean wind power density	W/m²
$\rho\bar{U}^3/2$	Power density from the mean speed alone	W/m²
$1 - F(U_x)$	Fraction of time above U_x	-
$\sigma_{Rayleigh}$	Standard deviation of a Rayleigh distribution with the same mean	m/s

Method and standards

Method of moments for the two-parameter Weibull distribution of wind speed.

Assumptions and limits

- Two-parameter Weibull; calms not separated.

Report details

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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-weibull-parameters-pattern-factor

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Reopens the calculator with the inputs of this report.