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Rotor Equivalent Wind Speed: One Power Curve or Two?

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Contents

- Issues of AEP calculations in practice
- Treatment of wind speed definition for turbulence correction

Status of Discussion

- Former meetings: It seems that some turbine suppliers believe that it is sufficient to provide just one power curve.

RR 2 Results: Impact of Rotor Equivalent Wind Speed on AEP Calculations

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Site	Exercise	SEP	SEP relative exercise 2.0
[-]	[-]	[kWh]	[%]
1	2.0	1569064	0.00
1	2.1	1577124	0.51
1	2.2	1569433	0.02
1	2.3	1577493	0.54
2	2.0	2473424	0.00
2	2.1	2466090	-0.30
2	2.2	2493317	0.80
2	2.3	2485983	0.51
3	2.0	953948	0.00
3	2.1	949636	-0.45
3	2.2	942217	-1.23
3	2.3	937905	-1.68

<1% in AEP

- If the impact of the wind speed definition on AEP-calculations is very low, it doesn’t matter which power curve is applied.

Then the provision of one power curve is sufficient!

Poor Practice Scenario

- Site Conditions: high negative impact of shear or veer on power curve
- Wind turbine supplier provides only a power curve for rotor equivalent wind speed (or a power curve valid for a hub height wind speed combined with low or normal shear)
- Developer does not have measurements of rotor equivalent wind speed in place, or he or his consultant is not aware of the impact of shear and veer on power curves
- Consequence: Developer or his consultant apply power curve as provided by the turbine supplier with site specific wind speed at hub height for AEP-calculation

AEP will be overestimated!

Solutions

Solution 1:

- Wind turbine supplier provides only a power curve for rotor equivalent wind speed (or a power curve valid for a hub height wind speed and low or normal shear):
  - Give clear warning on possibility of negative impact of shear and veer!
  - Provide clear range of validity of power curve!
  - Encourage assessment of site specific rotor equivalent wind speed rather than hub height wind speed, or
  - encourage to adjust power curve to site specific shear and veer conditions using HH wind speed!

Solution 2:

- Wind turbine supplier provides site specific power curve for HH wind speed (and site specific turbulence and air density)

Turbulence Correction and Rotor Equivalent Wind Speed

- Turbulence correction in case of wind resource assessment:

$$P_{corrected} = P_{given\_PC}(v) - P_{simulated,I-reference}(v) + P_{simulated,I-measured}(v)$$

$$P_{simulated} = \int_0^{\infty} P_{I=0}(v) f(v) dv$$

where f(v): Gaussian distribution determined by v and standard deviation of v within 10 minutes (σ_v)

$P_{I=0}$: zero turbulence power curve

- **Which v and σ_v is to be used if the given PC refers to the rotor equivalent wind speed?**
  - v and σ_v used in f(v) must match $P_{I=0}$
  - Don't apply $P_{I=0}$ referring to rotor equivalent wind speed with HH wind speed when integrating over the Gaussian distribution!

Case 1

- Given PC refers to:
  - rotor equivalent wind speed
  - a certain turbulence intensity I-ref
  - a certain air density, ρ-ref
- Consistent turbulence correction:
  - Derive zero turbulence power curve $P_{I=0}$ for rotor equivalent wind speed and for ρ-ref
  - Calculate I-measured from wind speed measurement at HH:

$$I_{measured} = \frac{\sigma_{v_{HH,measured}}}{v_{HH,measured}}$$

  - apply Gaussian distribution with density corrected v_{eq} and adjusted σ_v:

$$\sigma_{v,adjusted} = I_{measured} v_{eq,\rho-ref}$$

Case 2

- Given PC refers to:
  - HH wind speed
  - a certain turbulence intensity I-ref
  - a certain air density, ρ-ref
- Consistent turbulence correction:
  - Derive zero turbulence power curve $P_{I=0}$ for HH wind speed and for ρ-ref
  - Calculate I-measured from wind speed measurement at HH:

$$I_{measured} = \frac{\sigma_{v_{HH,measured}}}{v_{HH,measured}}$$

  - apply Gaussian distribution with density corrected v_{HH} and adjusted σ_v:

$$\sigma_{v,adjusted} = I_{measured} v_{HH,\rho-ref}$$