

Exam of the Modul Advanced wind farm planning WS 2024/2025

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Introduction:

Provided shape file shows wind farm planning area which already includes all exclusion zones, so please ignore any distances to roads or area boundaries. There is a 200m tip height restriction.

Lidar measurement position: 548207 E, 6061864 N (coordinate system: UTM ETRS89 Z32)

Task:

Layout: Please create two layouts one with the Vestas V150/4.5MW wind turbine and one with Enercon E-147 EP5 E2 5000 with maximum allowable hub height. The minimum distance requirement between turbines is 5 RD x 3.5 RD (5 rotor diameters in the main wind direction, 3.5 rotor diameters perpendicular to it).

1. Baseline layouts without flicker and noise requirements:

- Energy yield estimation incl. losses for both turbine types
- Table incl. standard losses:

Parkwirkungsgrad	%
Internal + external wake effect	%
Future wake effect	0,0%
Availability	3,0%
Turbine availability	3,0%
Balance of plant (substation)	0,0%
Grid availability	0,0%
Electrical	2,0%
Electrical losses	2,0%
Facility consumption	0,0%
Turbine performance	1,0%

Power curve	0,0%
High wind hysteresis	0,0%
Site specific adaption of power curve	0,0%
Sub-optimal performance	1,0%
Environmental	1,0%
Performance degradation not due to icing	0,5%
Performance degradation due to icing	0,5%
Shutdown due to icing, lightning, hail, etc.	0,0%
High and low temperature	0,0%
Site access	0,0%
Tree growth or felling	0,0%
Curtailments	0,0%
<i>Wind sector management</i>	<i>0,0%</i>
<i>Grid curtailment</i>	<i>0,0%</i>
<i>Noise</i>	<i>0,0%</i>
<i>Shadow</i>	<i>0,0%</i>
<i>Bat</i>	<i>0,0%</i>

Losses will be summarized as follows:

$$Total\ loss = 1 - (1 - loss_1) * (1 - loss_2) * ... * (1 - loss_n)$$

- c. Calculate LCOE, NPV and IRR for both layouts and save your calculations (need to be provided w. the report). Use the assumptions provided in the CommercialEvaluationOfWindfarm.xls
 - i. Capex:
 1. WTG Capex per MW: 1.05 MEUR/MW,
 2. Other Capex per MW: 0.35 MEUR/MW
 - ii. OPEX: O&M 80.000 EUR/WTG/year
 - iii. Lifetime: 35 years, opportunity cost of capital: 11%, remuneration rate: 65 EUR/MWh

2. Flicker and Noise Compliant Layouts

- a. Flicker and Noise requirements
 - i. Noise: Consider nearest immission points only, noise limit: 45 db(A) at night
 - ii. Flicker: Calculation according to worst case scenario
- b. For both baseline turbine layouts run a Flicker and noise calculation
- c. Report the outcome of the calculation and if necessary the changes (e.g. curtailments, turbine movement) to make the layout compliant to the noise and flicker restrictions
- d. Calculate Energy yield estimation incl. losses (please refer to task 1 for standard losses) for both compliant layouts and include

- i. Bat losses: shut down of WTGs from 01.04. until 31.09. from 1 hour before sunset until 1 hour after sunrise at wind speed $v < 6$ m/s
- e. Calculate and report LCOE, NPV and IRR for both compliant layouts
- f. Based on NPV pick the best compliant layout
- g. Calculate P75 and P90 AEP for the best compliant layout (Uncertainty 10%)

$$E_{\text{planned}} = E_{\text{calculated}} - E_{\text{reduction}}$$

$$E_{\text{reduction}} = f(p) * \sigma_E$$

$$\sigma_E = \text{Uncertainty} * E_{\text{calculated}}$$

$$f(75\%) = 0,67 \quad \text{for P75 AEP}$$

$$f(90\%) = 1,28 \quad \text{for P90 AEP}$$

Report:

- Report your calculations and findings.
- Explain the terms opportunity cost of capital, NPV, IRR and LCOE
- Please discuss: If you would have more time, which optimisation measures would you like to explore to optimise your wind farm? What are potential shortcomings in the suggested optimisations?