Design of Wind Energy Systems – Summer Term 2016
Tutorial 1: Annual energy production

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Assignment 1

A measurement campaign has been performed in order to evaluate the annual wind distribution in three different sites located in open farmland (few trees and buildings). The measurements were taken with a cup anemometer installed on a met-mast at the height of 30 m. The fit of the data to a Weibull distribution provided the scaling factor *A* and shape parameter *k* listed in Table 1.

Table 1: Site parameter

	A	*k*
Site A	6.65	1.9
Site B	8.90	2.0
Site C	11.80	2.2

Select in the catalogue of the company (Table 2) three wind turbines with a distinctly different specific rating. Evaluate for each turbine the available certification. www.wind-energy-market.de or wind turbine manufacturer brochures may be used as source for information.

For the given type class certification*, evaluate which turbine is compatible with which site and include it in Table 3.

Table 2: Wind turbine data

		Vestas V90 1.8 MW GridStreamer	GE 1.6 82.5	Vestas V112 3.0MW	Vensys 100	Gamesa G58 850 kW	Nordex N90 2500 HS	Repower 3.4 M104	Repower 3.4 M104	Repower 5M	Leitwind LTW70	Enercon E-82 E3	Enercon E-70 2.3	Enercon E-44	E-126/7.5 MW
Rated Power	**[kW]**	1800	1600	3000	2500	850	2500	3400	3400	5075	1700	3000	2300	900	7500
Rotor Diameter	**[m]**	90	82.5	112	99.8	58	90	104	104	126	70.1	82	71	44	127
Specific Rating	**[W/m^2]**														
Hub height	**[m]**	80	80	84	100	65	80	93	125	95	60	85	85	55	135

Table 3: Combination of selected wind turbines and suitable sites

Wind Turbine and Hub Height	IEC Type Class	Suitable Sites

Assignment 2

You are asked to evaluate the most suited wind turbine for three specific sites in relation to the annual energy production. Three sites characterized by the annual average wind speed at hub height of $V_{ave\ 1,2,3}$ = 7.5, 8.5 and 10 m/s respectively, are considered in combination with three wind turbines belonging to different categories of specific rating and IEC type class certification*.

a) Select a turbine from Vestas V90, Nordex N90 and Enercon E-82 (see Table 2) for each site according to the request.
b) Determine the fraction of time each turbine is idling below the cut-in speed, producing power at partial load, producing power at full load and is idling above the cut-out speed (Note: assume 100% availability).
c) Calculate for each turbine at the specific site the net annual energy production (98% availability, 3% grid losses, 10% contingency reduction), the capacity factor and the full load hours considering the power curves described in the provided spread-sheet.
d) Indicate the best combination turbine-site in terms of annual energy production and explain your choice by comparing and interpreting the results of a), b) and c).
e) Would you recommend the same turbine-site combination when the feed-in tariff offers an incentive for a certain guaranteed minimum power production?
f) Optional: Calculate the standardized power duration curve for the three turbines at their specific site (see Fig. 4 in J.P. Molly, Rated Power of Wind Turbines: What is Best? DEWI Magazin 38).

Table 4: Power production of wind turbines at the three sites

Site	Type Class Certifi-cation	Wind Turbine	Time [%]				AEP [GWh]	Full load hours	Capacity factor	Best case
			with u<cut-in	at partial load	at full load	with u>cut-out				
1										
2										
3										

Notes

I. The spread sheet with the power curve will be loaded on the STUDIP web-site of the course.

* In this assignment the turbulence characteristics of the site are not considered in the assessment of the required certification type class.