# Design of Wind Energy Systems – Summer Semester 2016
# Design-Tutorial 1: Selection of main parameters & rotor design

Prof. Dr. Martin Kühn

Bernd Kuhnle, Luis Vera-Tudela

## Introduction

In tutorial 1 you have selected the most suitable wind turbine for given site conditions and related your choice to specific rating. In this design-tutorial you will estimate other main parameters that will help you to define a wind turbine model and will compare it to commercial turbines.

Additionally, you will calculate airfoil aerodynamic properties from tables and define the geometry of your blade, which will be used in following tutorials.

## Section 1

Let's define the main parameters of your wind turbine and discuss some results.

1. Calculate total conversion efficiency (use Cp-reference, mechanical efficiency and electrical efficiency) and compare it to other technologies.
2. Using the total conversion efficiency, evaluate how much wind power has to be captured to obtain the nominal electrical power.
3. Estimate the rated wind speed and round it up. Use the reference max. blade length given.
4. Calculate the rotor radius using rated wind speed and round it up. Find exact blade length considering the hub radius.
5. Calculate the rotor area and the specific rating for your wind turbine. Compare results (3-5) with commercial wind turbines.
6. Determine rotor rated speed and design tip speed ratio. Use max. tip speed given.

Rayleigh distribution is typically assumed for design. When specifying a turbine for a specific local wind regime, some parameters must be optimized.

7. Estimate annual energy production for both Rayleigh and local wind regime. Explore what parameters can be optimized and how would they affect your results.

## Section 2

Select your airfoils and estimate their main aerodynamic properties.

8. Estimate the design lift coefficient, angle of attack and drag coefficient for each airfoil of your blade. Review the lift and drag curves for the selected profiles and comment. What is the range (in degrees) where the lift-to-drag ratio is high and where it is low? What does the NACA “XY”-“ABC” stands for? How will you determine which airfoil should be used in each blade section?

Hint: Optimal lift coefficient is defined as the point where the lift-to-drag-ratio is maximal. In this design you will use the values (degrees, lift and drag coefficient) when lift coefficient is equal to 80% of maximum lift coefficient. $c_{l_{design}} = max\left\{c_l\left(max\left(\frac{c_l}{c_d}\right)\right), 0.8 * c_{l_{max}}\right\}$