# Steady States Calculations

**Exercise to Lecture #8**
**Controller Design for Wind Turbines and Wind Farms**

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## 1 Calculation of Steady States for Baseline Torque Controller

With the script Exercise08_StaticCalculations.m and the case `NREL5MW\_FBNREL` in StaticCalculations_Config.m (line 39) we are calculating the steady states (rotor speed, tower top displacement, pitch angle and generator torque) for the baseline torque controller. Please perform the following tasks:

a) Calculate the rated wind speed within the script HowToFindRatedWindSpeed.m using `fminbnd` and `fminunc` and the function OmegaDot.m. Copy the solution using into StaticCalculations_Config.m.
b) Adjust the calculations for the steady states calculations in Exercise08_StaticCalculations.m (Section 4.2) for the cases `'StateFeedback'` and `'3'`.

## 2 Calculation of Steady States for Advanced Torque Controller

With the script Exercise08_StaticCalculations.m and the case `NREL5MW\_FBSWE` in StaticCalculations_Config.m (line 39) we are calculating the steady states (rotor speed, tower top displacement, pitch angle and generator torque) for the advanced torque controller.

a) Adjust the case `NREL5MW\_FBSWE` in StaticCalculations_Config.m based on case `NREL5MW\_FBNREL`. You need to set `FlagPITorqueControl` to 1 and add calculations for `Parameter.VSC.v\_1to1d5, Parameter.VSC.v\_1d5to2, Parameter.VSC.v\_2to2d5` similar to `Parameter.VSC.v\_rated`.
b) Calculate the steady states for the advanced (PI) torque controller by adjusting Exercise08_StaticCalculations.m (Section 4.1) and adding the cases `1, 1.5, 2.5` in Section 4.2.
c) Compare the energy gain between the advanced (PI) torque controller and the baseline torque controller and estimate the increase in AEP using a Weibull distribution for Wind turbine class I.

## 3 Calculation of Steady States for Baseline Controller Using FAST

Run steady state simulation for every 1 m/s using the baseline controller DLL from Exercise 4. Use a simulation length of 60 s or more and average over the last 3 revolutions. Compare the steady states from FAST to the ones from SLOW. You can use the steady states for tower displacement, rotor speed and pitch angle from SLOW to initiate FAST.