ECE 566: Grid Integration of Wind Energy Systems

Offered Spring semester of 2021

Course Description: The modern electricity grid is evolving to include increasing numbers of variable and renewable generation sources. This course covers several aspects of wind energy conversion systems (WECS) and their interconnection to the power grid. The course provides students with the background to understand, model and simulate a complete wind turbine system, including the wind resource, mechanical torque production, electrical motor and drive system responses. Various wind turbine topologies and control concepts are covered. The integration and impact of wind generators on the power grid are also discussed.

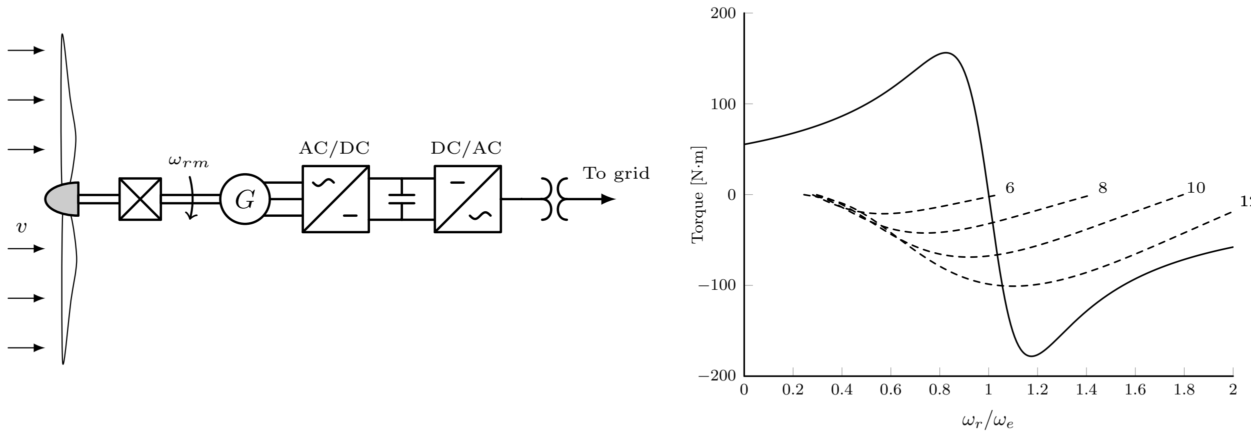

Fig. 1: (left) notional wind turbine system, (right) generator electromagnetic torque (solid), and mechanical torque (dashed) for wind velocities $v \in \{6, 8, 10, 12\}$ [m/s].

Course Objectives: This course introduces concepts of grid integration of wind energy conversion systems building upon the basic foundations and operating principles of electrical generators used in wind conversion, interfacing power conversion electronics and their controls. Upon completion of the course students will:

- Understand the basic concepts of wind energy power plants and conversion systems;
- Comprehend how to model electrical generators and power electronics used in WECS;
- Demonstrate the simulation of basic wind turbine systems;
- Appreciate the grid impacts of WECS;
- Understand alternative architectures and control concepts associated with WECS.

Prerequisites†

- ECE 461/462 Power Systems-I/Laboratory OR ECE 565 Electric Power Engineering AND
- Working knowledge of MATLAB/Simulink (or similar software) is *required*.
- ENGR 570 Coupled Electromechanical Systems is recommended, but not required

Textbooks

(Required): S. Heier. *Grid integration of wind energy conversion systems.* 3rd Ed. John Wiley & Sons: W. Sussex, England, 2014. ISBN: 978-1-119-96294-6.

(Supplementary, but not required): P.C. Krause, O. Wasynczuk, S. Sudhoff, *Analysis of Electric Machinery*, Wiley/IEEE Press, 1995. ISBN: 978-0-780-31101-5.

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†Contact the instructor (jcale@colostate.edu) with questions and/or requests for waivers for the prerequisites.

Other References

During the semester the instructor will provide course notes, relevant monographs and research articles from public domain and electronic databases accessible via CSU libraries.

Course Grading Weights

Homework:	20%
Mid-term exam:	30%
Simulation Project 1:	25%
Simulation Project 2:	25%

Professor: Dr. James Cale

Prof. Cale has extensive experience in modeling and simulation of electric motors, drive systems and controls for renewable energy applications. His background and research focuses on energy conversion, power electronics, computational and applied electromagnetics, nonlinear optimization methods, and microgrids. Prior to joining CSU he led the Distributed Energy Systems Integration Group at the National Renewable Energy Laboratory and worked in senior power engineering roles at Advanced Energy and Orbital ATK. He earned his doctorate in electrical engineering from Purdue University and bachelors degree in electrical engineering (*summa cum laude*) from Missouri University of Science & Technology.

Note: This course was originally conceived and designed by Prof. S. Suryanarayanan, currently with South Dakota State University. The current version of this course includes modifications done by Prof. Cale with Prof. Suryanarayanan's consent.