ECE 4200 & 6200 All Sections
Renewable Energy Grid Penetration

Class Location/Time: **Rhodes Annex 111 & ZGEC-102 with Online,**
Tuesday, Thursday 11 AM -12:15 PM

Instructor: **Prof Johan H Enslin** **Email: jenslin@clemson.edu** **Office: Z-GEC 109**
Office Hours: **After class or by appointment**

Teaching Assistant/Grader: **Fatemeh Tooryan ftoorya@g.clemson.edu /**
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Course Description

Integration of large-scale distributed renewable energy resources (DER) into the electric grid introduces real-time and near real-time system operational challenges around reliability and security of the power supply.

This course introduces the basic definition of electrical power, interfacing primary sources, generator/load characteristics, and renewable energy resources. Topics include solar energy grid integration, wind energy grid integration, energy storage management, harmonic distortion, voltage sags, and national standards.

Prerequisite: ECE 2070 or ECE 3200, each with a C or better.

Course Objectives

The main objectives of the course are:

- Provide in-depth knowledge on interconnecting renewable energy resources, industry emerging trends, standards, policy and regulations.
- Basic definition of electrical power, interfacing primary sources, generator/load characteristics, and renewable energy resources.
- Topics include solar energy grid integration, wind energy grid integration, energy storage management, harmonic distortion, voltage sags and national standards.
- Provide an opportunity to apply learnings though practical and hands-on case modeling of renewable energy sources.

Required Materials

1. Required: Renewable and Efficient Electric Power Systems, 2nd edition, by Gilbert M. Masters, ISBN: 978-1118140628.

2. Course Notes

3. Useful References:
    a. Photovoltaic power system: modelling, design and control, by Weidong Xiao, Wiley 2017.
    b. Microgrid dynamics and control, by Hassan Bevrani, et al, Wiley 2017.
    c. Electric Energy: An Introduction, Third edition, by El-Sharkawi, CRC Press, 2013.
    d. Design of Smart Power Grid Renewable Energy Systems, by A. Keyhani, John Wiley & Sons, Inc., 2011.

Topical Outline

Classroom Policies: Class attendance is compulsory for this class through attendance register and Quiz Tests, see Undergraduate Catalog for guidance. Class attendance is critical to the educational process. In the event of a true emergency, the student should make direct contact with the course instructor, preferably before a class or an exam takes place. Students should also develop a plan for any make-up work. It is the
student's responsibility to secure documentation of emergencies, if required. A student with an excessive number of absences may be withdrawn at the discretion of the course instructor. No make up for missed classes, exams, or assignments will be given. Students are required to be present for the final examination and tests. Students are responsible for all material covered, all extra material assigned for reading and all assignments given. Some lectures may cover material not found in the textbook. It is the responsibility of each student to make up any deficiencies that result from missed classes. Students are expected to wait 15 minutes before leaving if the instructor is late. Cell phones must be turned off or silenced before coming into class.

Note that the design project, assignments, exams and requirements for ECE-6200 (graduate students) are different from ECE-4200 (undergraduate students).

Class Schedule for Spring 2020 is shown below. Some classes will be in workshop format. Students are expected to present their findings and assignment results in the class.

Course Outline:

Chapter 1	The U.S. Electric Power Industry
Chapter 2	Basic Electric and Magnetic Circuits (Self study)
Chapter 3	Fundamentals of Electric Power (Review)
Chapter 4	Solar Resources
Chapter 5	PV Materials and Electrical Characteristics
Chapter 6	Photovoltaic Systems
Chapter 7	Wind Power Systems
Chapter 9 & M1	Smart Grid and Energy Storage
External M2	Voltage Drop and Power Loss Calculations
External M3	PV and Wind Converter Applications and Characteristics
External M4	Distribution System Voltage Regulation
External M5	Power Quality and System Reliability
External M6	Impacts on T&D System Protection

Important Dates:
First Class: Thursday January 9, 2020
Last Day to Register for a Class: January 14, 2020
Last Day to Drop a Class with "W" Grade: January 22, 2020
Last Day to Drop a Class without a Final Grade: March 13, 2020
Spring Break: March 16-20, 2020
Final Exams: April 27 — May 1, 2020; Scheduled for Wed. 4/29/2020 at 3-5:30pm

Grading

There are frequent project assignments and a comprehensive system design for this course. A final term paper on the project in IEEE format, the design and simulation information and models, will be the Design Project deliverable.

The weight of each item and the final grade is as follows:

	ECE-4200:	ECE-6200:	Dates:
Homework Assignments	20	15	Throughout Semester
Design and Simulation Project	15	25	April 9th before class.
Mid-term Exams (2)	30	25	3/5 and 4/16
Class Attendance	5	5	Ongoing
Final Exam*	30	30	Wed. 4/29/2020 at 3-5:30pm
Total	100	100	

Grading Scale:
Below is the letter grade scale that will be used in this class:

Undergraduate Students (4200):
A = 90 – 100 %
B = 80 – 89 %
C = 70 – 79 %
D = 60 – 69 %
F = Below 60 %

Graduate Students (6200):
A: 90 – 100%
B: 80 – 89%
C: 70 – 79%
F: 70 % and below

Exams: All students must attend all tests and exams. Makeup tests will not be given under any circumstances. A student who misses a test or the final examination for any reason will receive a grade of zero for that test or examination. To accommodate students who must miss class when a test is given because of a true and documented personal emergency, significant illness or other circumstances beyond their control, the final examination score will be substituted for the missed test score.

All exams and tests are closed book and notes. One double page of notes and equations are allowed and need to be handed in for possible bonus points. No computers with network access are allowed and all smart phones need to be on airplane mode. All questions and problems regarding grades must be presented within one week after the test, homework, or project has been retuned.

Tentative dates for the tests are during the class as follows:

Test 1:	Tuesday, March 5, 2020
Test 2:	Tuesday, April 16, 2020

Final Examination: Wed. 4/29/2020 at 3-5:30pm

*Final exam is optional for all students. If a student receives 90% or above in each midterm test, they may be exempted from the final exam if they chose to do so. The final exam is comprehensive on all the class materials.

Design and Simulation Project (Team Project): There is a comprehensive system design for this course. Details for the project will be provided in a separate file later. A final term paper on the project in IEEE format, the design and simulation information and models, will be counted as the Design Project deliverable. For undergraduates a maximum of four (4) students may participate in a team and for Graduate students a maximum of two (2) will form a team.

Homework: All homework will be collected at the beginning of the class period in which it is due (Thursday classes). Students are expected to complete all assignments. Late homework will not be accepted. If you are going to miss a class where homework is due, you must turn it in beforehand or receive a zero on the assignment. All homework must be legible and use of engineering or computer paper is preferred. Submissions that cannot be read will be marked wrong.

Class Attendance Grade: The attendance grade will be calculated from attendance register and quizzes.

Bonus Points: Bonus points may be added to the total grade during the semester. Bonuses may include IEEE/PES seminars, field trips, and announced bonus homework.

Changes to Syllabus: The instructor reserves the right to make changes to this syllabus during the semester. Students will be given adequate notice in class of any changes.

Students with Disabilities: Students with disabilities who need accommodations should contact the instructor with a Faculty Accommodation Letter from Student Disability Services as soon as possible

in order to ensure proper accommodations can be made for the student. The student must notify the instructor at least one week before any test for which accommodations are needed.

Collaboration with classmates on homework assignments is encouraged, however you may not copy solutions and all work submitted must be your own. No work from prior classes may be submitted. Any violations of these policies will be reported to the University.

Additional Policies

See Policy - ECE Common Course Syllabus - Spring 2020.