ECE 8930 All Sections
MicroGrids in Virtual Power Plants

Meeting Time: Zoom/WebEx Wednesdays: 2:00 – 4:30 PM, or as scheduled
Course Modality: ONLINE SYNCHRONOUS, or as designated in CANVAS / IROAR
Class Location: Zoom/WebEx, or as designated

Instructor: Prof Johan Enslin **Email: jenslin@clemson.edu** **Office: GEC 109**
e-Office Hours: Per appointment **Office Phone: 843-730-5117**

Teaching Assistant/Grader (if applicable): Ali Arzani
Email: aarzani@clemson.edu **Office and Office Hours: Via email**

Course Description

Integration of large-scale distributed energy resources (DER) into the electric grid introduces real-time and near real-time system operational challenges around reliability, physical and cyber security of the power supply. These challenges, if not addressed properly, will result in unexpected grid failures, impacting financial performance of the utility's and business' operations and utility's public relationship image. To effectively address these challenges, it is necessary to plan, engineer/design and operate the electric grid with holistic and end-to-end solutions with MicroGrid concepts. This course will address both technical and financial options for designing, controlling and operating a MicroGrid.

By adding more converter-based generation from solar and wind energy in Distributed Energy Resources (DER) into a MicroGrids, in conjunction with retiring traditional steam generators, the traditional power system is losing spinning reserves and system inertia. Significant mechanical inertia of the rotor in a synchronous generator is crucial for facilitating the cooperative grid forming capability. Thus, the control of multiple DER resources in grid-following and grid-forming systems, representing grid-tied and islanded systems, on the distribution network will be the focus of this course using a realistic system design.

COURSE PREREQUISITES: Senior-level courses in power systems, renewables and/or power electronics is highly recommended.

Course Objectives and Student Learning Outcomes:

At the completion of the course, students should be able to:

- Understand and provide in-depth knowledge on industry emerging trends, standards, policy, regulation and progress with development and deployment of integrated MicroGrid solutions, innovative technologies and advanced applications enabling DER's scale deployment.
- Model and control MicroGrids and VPPs
- Understand Communications, Operational Aspects of integrating MicroGrids in a VPP
- Understand Cyber and Physical grid security aspects of integrating MicroGrids

- Be able to develop a business case for cost-effective DER deployment, considering benefits to all energy stakeholders.
- Apply learnings though practical and hands-on use-case modeling of MicroGrids with Hardware-in-the-Loop (HIL) tools.
- Write and present term paper of analysis and market options.

Required and Recommended Materials

1. Research Journal and Conference Papers
2. Renewable and Efficient Electric Power Systems 2nd edition: Gilbert M. Masters, ISBN: 978-1118140628.
3. Microgrid dynamics and control, by Hassan Bevrani, et al, Wiley 2017, ISBN: 9781119263692
4. Course Notes
5. Useful References:
    a. Photovoltaic power system: modelling, design and control, by Weidong Xiao, Wiley 2017.
    b. Electric Energy: An Introduction, Third edition, by El-Sharkawi, CRC Press, 2013.
    c. Design of Smart Power Grid Renewable Energy Systems, by A. Keyhani, John Wiley & Sons, Inc., 2011.

6. Each student is required to have a laptop computer, internet connectivity capable of transmitting and receiving video, a video camera, a microphone, do modeling with remote campus access and a cell phone.

Topical Outline

Class Schedule for Fall 2020 shown below or as announced through CANVAS. Classes will be in workshop format. Students are expected to present findings and assignment results.

Weeks 1 - 5: Background Materials on VPPs, Renewables, Energy Storage and MicroGrids.
Weeks 6–10: MicroGrid Modeling and Design
Weeks 10–15: Analysis and presenting results.

Term Paper Due: Dec 6, 2020 (May vary – See Modification Statement)

Grading

There is a project assignment that include a comprehensive simulation and modeling for control and evaluation of MicroGrids. A final term paper in IEEE format will be the final deliverable. The weight of each item and the final grade is as follows:

Practical and Analysis Projects (2 Students per team): 40%
Class Participation and Teamwork: 10%
Final Term Paper (Individual): 50%

Final Grade Levels:

A+: 95 - 100%; A: 90 – 94%
B+: 85 – 89%; B: 80 – 84%;
C: 70 – 79%
F: 70 % and below

The detailed course and project schedule will be provided during the course through CANVAS.

Attendance Policy

Online synchronous classes: Meetings, including presentations and workshops are scheduled during the published meeting times with the following:

1. Synchronous online mode will be in the form of a workshop where each student needs to be prepared to discuss his/her progress.
2. Online attendance is mandatory with team participation. Notification of Absence needs to be sent via email to the instructor.
3. In the event of a class being cancellation, a CANVAS notification will be sent out.

Additional Policies

ACCESSIBILITY STATEMENT: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to a class should let the instructor know and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848 or by emailing studentaccess@lists.clemson.edu. Students who receive Academic Access Letters are strongly encouraged to request, obtain, and present these to their instructors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here: http://www.clemson.edu/campus-life/campus-services/sds/.

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SAFE CAMPUS: Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

a. Ensure you are signed up for emergency alerts (https://www.getrave.com/login/clemson)
b. Download the Rave Guardian app to your phone (https://www.clemson.edu/cusafety/cupd/rave-guardian/)
c. Learn what you can do to prepare yourself in the event of an active threat (http://www.clemson.edu/cusafety/EmergencyManagement/)

ACADEMIC INTEGRITY: As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity. Further information on Academic Integrity can be found in the Undergraduate Announcements and in the Graduate School Policy Handbook.

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MODIFICATION STATEMENT: The instructor reserves the right to modify any aspect of the syllabus at any time during the semester for reasons including but not limited to COVID-related situations.