Course Syllabus

MICROGRID SEMINAR

EOS 792S-01, Fall 2021

Tuesdays 3:30 AM - 4:45 PM – Rm. 1111, Grainger Hall

Instructor

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COURSE DESCRIPTION

This seminar will focus on designing and costing microgrids. Microgrids are formally defined as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid".[1] In other words, these are local energy grids with control capability, allowing them to be disconnected from the conventional grid and operated autonomously.[2] Examples of microgrids range from building to campus to community power systems that are connected to the conventional electric grid but can be islanded off from it, to systems that power remote facilities beyond and thus totally disconnected from the grid. Designing a microgrid entails more than simply hooking up distributed generation technologies to one or more loads. It also involves understanding existing regulations regarding microgrids and the circumstances under which they can be connected to conventional grids, resolving ownership of the microgrid and/or its components, correctly estimating the available resources for generating local power, properly forecasting microgrid costs and thus benefits relative to continuing to rely on the conventional grid, and ensuring that the generation resources in a microgrid meet existing load requirements, including amounts of power delivered as well as the timing and reliability of that power delivery. After reviewing these issues, this seminar will explore how to analyze both load data and data on local renewable energy resource potential. These analyses will serve as the input to calculations of the potential power output from different distributed energy technologies, including how much this output might vary over time. Finally, we will analyze financial models of microgrid costs, including the using sensitivity tests to more accurately constrain microgrid economics. The seminar will conclude with each student presenting their design and projected costs for a potential microgrid project; a project that they will be assigned the second or third week of class.

COURSE OBJECTIVES

By the end of this course, you should be able to:

- Model a microgrid using the HOMER Legacy software.
- Explain the basic regulatory, economic and technical issues that need to be addressed in setting up a microgrid.
- Analyze data of the loads to be partially to fully met by a microgrid.
- Estimate local resources for generating power using publicly available data.
- Calculate power output for different power producing technologies from equations commonly used to model these technologies.
- Understand how microgrid controllers autonomously manage generators to meet loads within a microgrid.
- Interpret pro forma cash flow models of microgrid costs as well as any potential revenues.

COURSE PRE-REQUISITES

In order to take this course, you should have already completed Energy & Environment (ENV711), Energy Modeling (ENV716), and Energy Technology (ENV631). Other courses that you are recommended to have completed are Power Markets (ENV717), Applied Data Analysis (ENV710) and Buildings & Energy (ENV830).

GRADING

Grades will be based on:

- Class participation: 30% of final grade
- Team presentations of class project: 30% of final grade
- Individual final report of class project: 30% of final grade
- Class assignments : 10% of final grade

CLASS PROJECT

You and your team constitute a “consulting firm that specializes in developing microgrids”. Your job is to develop an design proposal for installing a microgrid for part of Duke University’s campus. Instructions for what your proposal is to include will be provided two weeks after the start of the semester. Prior to that, you will form a consulting team and be assigned your campus area within one week after the start of the semester. Data on your installation will include the buildings’ electric and heating/cooling use. The majority of the course will be geared toward stepping you and your team through designing your microgrid using HOMER, a software package for modeling microgrids. Classes will also provide additional context for what in fact you are modeling.

TEAM PRESENTATIONS

During two of the last classes of the course (see schedule below), you and your team will present your microgrid design to the rest of the class. PowerPoints of the slides you’ll be using in your presentation are due the class period before the classes during which the presentations will be made. Instructions for the presentations will be posted by mid-semester along with the presentation grading rubric.

INDIVIDUAL FINAL REPORT

You will be responsible for preparing a written assessment of your team’s specific proposal. Note, that your assessment is to be completed by you and you alone. Detailed instructions on what the assessment should address and how it will be graded will be released by mid-semester. For now, know that your assessment, with figures and references, is to be no more than five pages, single-spaced in no less than 10 pt. font. If you have ancillary supporting information you feel is important to include, include it in an appendix, but everything else should fall within the 5-p limit. Please remember to reference anything that is not your work or is not general knowledge. See the following link for the format I would like you to use: http://www.chicagomanualofstyle.org/tools_citationguide/citation-guide-2.html.

ASSIGNMENTS

Following the 2nd class on 8/31 and continuing through the 10th class on 10/13, a brief team assignment will be posted on Sakai for you and your team to complete and submit by the start of the next class (e.g., the assignment posted after class on Tue, 8/25, will be due by the start of class on Tue, 9/1). There will be a total of eight of these team assignments. Each will be designed to help you and your team gather necessary information from which to develop your proposal, including modeling it using Homer Pro, the microgrid modeling software that we will be using. Each assignment will be graded as either excellent, very good, good or poor, based on (1) my personal judgement of the quality of the team’s work, and (2) how a team’s assignment stacks up with respect those submitted by the other teams. Note, however, that the assignments count towards a relatively minor part of your final grade and, again, are meant to keep you on track towards completing your team presentation and your final proposal, so in grading of the assignments, I will be looking for you to have gotten what I want you to get out of them and will not be so focused on them being completed perfectly.

CLASS FORMAT

This is a seminar, meaning that the emphasis in class will be on learning through discussion. While I will lecture for a good bit of the time, I will often question you to foster critical thinking and drive our discussions towards particular learning objectives. We will also spend time as a class reviewing challenges and successes in working with load and renewable energy resource data, and, for example, in exploring the pros and cons of different energy technologies are often modeled. Be sure to contribute to the discussion, because class participation is a big part of your grade.

READINGS

There is no formal text for this course. Most of what you will learn will come from managing and analyzing actual data and from our discussions. Scientific papers, reports and/or book chapters may be assigned ahead of time to facilitate in-class discussion or after a class to clarify and more fully explain what we have discussed.

SOFTWARE

You will use HOMER Pro to design your microgrid. HOMER Pro is commercial software originally developed at the U.S. Department of Energy’s National Renewable Energy Laboratory as a tool for finding affordable energy solutions for village power. There used to be an earlier, free version referred to as Homer Legacy, but it is no longer available. In place of it, the parent company, Homer Energy, offers student licenses for lease on a monthly to annual basis. You run these on your personal computer. The package you wi need is the Advance On-Grid version. It runs $25/mo. We will not need the software in August, so I recommend leasing it for September through November, which will run $75 total.

SAKAI

Readings, class announcements, schedule changes, grades, power point slides and data files will all be posted to the course Sakai site. Anyone having trouble working with the site should seek help from their fellow students, or contact the Office of Information Technology (http://oit.duke.edu).

CLASSROOM ETIQUETTE

- Computers allowed, but only for class activities, e.g., taking notes and researching questions that arise in class.
- Cell phones - off.
- Food & drinks – Not allowed during the pandemic.
- Side conversations are discouraged during class.
- BE ON TIME FOR CLASS.

POLICY ON CLASS ABSENCES

If you are ill or have a family emergency that prevents you from being able to attend class and thus miss a quiz and/or a test, please submit the web-based short-term illness form prior to class. The short-term illness form can be found at:

www.aas.duke.edu/trinity/t-reqs/illness/

You are governed by the Duke University Honor Code in completing this form (see below). Those with excused absences can take a makeup quiz/test for the missed class. Know though that the makeup will be notably more challenging than the original quiz/test. Those without an excuse will receive a quiz/test grade of zero.

THE DUKE COMMUNITY STANDARD

All activities of Duke students, including those in this course, are governed by the Duke Community Standard, which states:

"Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity. To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised."

The following affirmation will be included at the end of all assignments: "I have adhered to the Duke Community Standard in completing this assignment." Please sign your nam beside it.

SYLLABUS

This syllabus is subject to change based on the pace and/or needs of the class. Any revisions will be announced in class and, if necessary, an updated syllabus will be posted on Sakai. Students will be held responsible for all changes.

INITIAL SEMINAR SCHEDULE (some topics subject to change)

Assignments due by the beginning of the next class.

Date	Topic	Team Assignment
Tue, 8/24	Microgrids: what they are, why build one, and what to consider	None
Tue, 8/31	Understanding the regulatory risks associated with microgrids (teams assigned building types & locations)	Complete regulation worksheet
Tue, 9/7	Defining segments of Duke's campus to model microgrids for	Subdivide into two teams
Tue, 9/14	Establishing the goals and preliminary design of a microgrid	Develop a schematic of the energy assets and loads for your building type. Calculate your building loads and identify critical, important but interruptible and shed-able loads

Tue, 9/21	Determining load and reliability constraints	(import building load data into HOMER and use the software to help in the analysis)
Tue, 9/28	Assessing distributed energy resource potential	Download and input resource data. Fill out resource assessment worksheet.
Tue, 10/5	FALL BREAK	
Tue, 10/12	Possible microgrid components	Identify the type of microgrid components you wish to explore using with your buildings and fill out the microgrid component worksheet.
Tue, 10/19	NO CLASS**	Begin simulating microgrid scenarios.
Tue, 10/26	Microgrid controllers and network operations	Fill out controller and network operations worksheet.
Tue, 11/2	Simulating microgrid performance	Fill out microgrid simulation worksheet.
Tue, 11/9	Financial modeling of microgrids	Complete and submit PPT of Team Design Plan
Tue, 11/16	Team presentations and discussion	Casey Collins, Duke Facilities Energy Manager, and Tim Johnson, NSOE Assoc. Dean, join class
Tue, 11/23	Final reports due	Complete and submit final report testing business plan for your building/state

**I am away this week leading a Duke Alumni Fieldtrip.

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[1] https://building-microgrid.lbl.gov/microgrid-definitions

[2] https://energy.gov/articles/how-microgrids-work