Course Syllabus

[Jump to Today](#)

ENVIRON/ENERGY 590 - Economics of Modern Power Systems

Course Overview

Class Hours

M-W 13:25 to 14:40 Gross Hall 100C (The Generator)

Instructor

Luana Medeiros Marangon Lima
Office: Gross Hall - 102
E-mail: luana.marangon.lima@duke.edu
Office hours: Wed 12:15-13:15pm (Gross Hall 102K or [**Luana's Zoom** ⤷
(https://duke.zoom.us/my/luanalima)]), or by appointment.

Teaching Assistant

Marcio Ribeiro

Visiting Scholar (Post-Graduate Program in Energy at the Energy and Environment Institute of the University of São Paulo)

marcio.ribeiro@duke.edu (mailto:marcio.ribeiro@duke.edu)

Office hours: Mondays 10:00 - 12:00 (Grainger Hall 3120)

Communication

We will use Slack for communication. I will add all students to the slack workspace I've created for the class. Using slack will assure I never miss a message from you and will also help build the cohort and the sense of community among ourselves. You may use slack on your computer and/or phone. Click **here** ⬦ **(https://join.slack.com/t/duke-31z9135/shared_invite/zt-2pefqiewk-pFs1PsrFmBCWwO6YTqzkqQ)** to join our slack workspace.

Course Description

The electric power grid is in the midst of a significant transformation, driven by the increasing penetration of renewable energy and the evolving demands of modern consumers. On the generation side, we are witnessing a surge in renewable energy integration as part of global efforts to reduce CO_2 emissions and combat climate change. On the demand side, the rise of electric vehicles, smart homes, and smart buildings is reshaping consumption patterns and challenging traditional grid management.

This course explores the economics of modern power grids, focusing on how to effectively integrate these emerging technologies and new agents. Students will gain a comprehensive understanding of the additional strains placed on existing grids to balance electricity supply and demand in a dynamic environment. We will examine the critical role of energy storage in managing the intermittent and fluctuating nature of renewable energy sources, as well as the complexities of distribution network pricing, including access charges and rate structures. These pricing mechanisms are crucial for the success of the Smart Grid, as they send the economic signals to network users.

Students will also explore how information and communication technology (ICT) is being integrated into every aspect of electricity generation, delivery, and consumption. This integration is essential for minimizing environmental impact while enhancing grid reliability and efficiency. By the end of the course, students will have a deep understanding of the economic, technological, and regulatory factors shaping the future of the power grid, preparing them to contribute to the development of sustainable and resilient energy systems.

Course Format and Grading

The course consists of in-person lectures and discussions based on the readings. There will be a set of assignments (40%), a journal (30%) and a final project (30%). You will work on assignments and journal in groups of two to ensure you are getting to know each other and also getting experience working as a team. There will be 5 assignments. The assignments involve reading and applying concepts and tools learned in class to an specific data set or problem. For the assignment you can choose your own group. But for the journal you will be rotating pairs. Two students should not work together for more than one week. More information to come later once I have the final number of enrolled students.

Wellness & Mental Health Resources

Your mental and physical wellbeing is integral to your ability to be academically successful. Below, we have compiled a list of resources around campus that are available to support you. If there is something going on in your personal life that is preventing you from participating fully in this or other courses, please feel free to speak with any of us. You are welcome to share as much or as little as you are comfortable sharing, and we are more than happy to arrange to get you the support you need.

Counseling and Psychological Services: CAPS helps Duke Students enhance strengths and develop abilities to successfully live, grow and learn in their personal and academic lives. We offer many services to Duke undergraduate, graduate, and professional students, including brief individual and group counseling, couples counseling and more. CAPS staff also provide outreach to student groups, particularly programs supportive of at-risk populations, on a wide range of issues impacting them in various aspects of campus life.

Duke Reach: DukeReach directs students, faculty, staff, parents, and others to the resources available to help a student in need. DukeReach is located in the Dean of Students Office and works with departments and groups across campus and in the community, including Housing, CAPS, Student Health, community health providers, the Academic Resource Center, and more.

DuWell: DuWell helps students focus on their individual wellness by looking at the integration of many areas of their life through areas of wellness promotion and risk mitigation.We engage students through a variety of wellness experiences across campus in an effort to reduce stress and anxiety while emphasizing self-care.

We are always available if a student needs someone to listen or to connect them with resources. As employees of Duke, we are mandatory reporters, meaning that if we receive a report of sexual assault, we are required to confidentially report this to the Office of Student Conduct (OSC). The OSC will follow up with the student to provide further information, but the student is not required to respond

and the conversation will not be shared beyond ourselves and the OSC. The following resources around campus are are not mandatory reporters: The Women's Center, medical providers, campus clergy, and CAPS counselors.

Class Etiquette

You should take responsibility for your education. I expect students to attend every class and get to class on time. If you must enter the class late, please do so quietly. Retain from using phones and tablets for social media during class. Some classes will involve coding on your laptop. I expect you to focus on the assignment and refrain from any web browsing that may disrupt the progress of your work.

Your classmates deserve your respect and support. We will likely have students from many different backgrounds and countries in this class and you should all feel comfortable and make each other comfortable while participating.

Nicholas School Honor Code

All activities of Nicholas School 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."

Please add the following affirmation to the end of all assignments, and sign your name beside it: "I have adhered to the Duke Community Standard in completing this assignment."

Policy for the use of Artificial Intelligence (AI)

We recognize that Artificial Intelligence (AI) is an emerging and powerful tool that can enhance learning and creativity. You are encouraged to explore the use of AI in your coursework; however, this

must be done with integrity and responsibility. The following guidelines apply:

1. **Critical Engagement:** You may use AI to assist in generating ideas, code, or text. However, you must critically evaluate and refine any AI-generated content before submitting it. Blindly submitting AI-generated work without proper review and modification is not acceptable.

2. **Transparency and Citation:** In the spirit of learning and transparency, you must clearly indicate where and how AI has been used in your work. This includes citing the specific AI tool used, detailing the prompts or inputs provided, and explaining the role AI played in the final product.

3. **Academic Integrity:** Failing to disclose the use of AI in your assignments will be considered a violation of the honor code. Proper acknowledgment of AI's contribution is essential to maintaining the integrity of your work.

Land Acknowledgment

"What is now Durham was originally the territory of several Native nations, including Tutelo (TOO-tee-lo) and Saponi (suh-POE-nee) - speaking peoples. Many of their communities were displaced or killed through war, disease, and colonial expansion. Today, the Triangle is surrounded by contemporary Native nations, the descendants of Tutelo, Saponi, and other Indigenous peoples who survived early colonization. These nations include the Haliwa-Saponi (HALL-i-wa suh-POE-nee), Sappony (suh-POE-nee), and Occaneechi (oh-kuh-NEE-chee) Band of Saponi. North Carolina's Research Triangle is also home to a thriving urban Native American community who represent Native nations from across the United States. Together, these Indigenous nations and communities contribute to North Carolina's ranking as the state with the largest Native American population east of Oklahoma.

Course Summary:

Date	Details	Due
Mon Aug 26, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71967&include_contexts=course_38941)**	1pm to 2:45pm
Wed Aug 28, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71968&include_contexts=course_38941)**	1pm to 2:45pm

Fri Aug 30, 2024	🗨 **A0 - Introduce yourself** **(https://canvas.duke.edu/courses/38941/assignments/142876)**	due by 11:59pm
Mon Sep 2, 2024	🗓 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71969&include_contexts=course_38941)**	1pm to 2:45pm
Wed Sep 4, 2024	🗓 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71970&include_contexts=course_38941)**	1pm to 2:45pm
Fri Sep 6, 2024	🗨 **A1 - Journal/Reflection on M1** **(https://canvas.duke.edu/courses/38941/assignments/157140)**	due by 11:59pm
Mon Sep 9, 2024	🗓 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71971&include_contexts=course_38941)**	1pm to 2:45pm
Wed Sep 11, 2024	🗓 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71972&include_contexts=course_38941)**	1pm to 2:45pm
Fri Sep 13, 2024	🗨 **A2 - Journal/Reflection on M2** **(https://canvas.duke.edu/courses/38941/assignments/157141)**	due by 11:59pm
Mon Sep 16, 2024	🗓 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71973&include_contexts=course_38941)**	1pm to 2:45pm
Wed Sep 18, 2024	🗓 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71974&include_contexts=course_38941)**	1pm to 2:45pm
Mon Sep 23, 2024	🗓 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24 (https://canvas.duke.edu/calendar? event_id=71975&include_contexts=course_38941)**	1pm to 2:45pm

Wed Sep 25, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar?event_id=71976&include_contexts=course_38941)	1pm to 2:45pm
	📝 **A3 - Residential Rooftop Analysis** (https://canvas.duke.edu/courses/38941/assignments/157346)	due by 11:59pm
Mon Sep 30, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar?event_id=71977&include_contexts=course_38941)	1pm to 2:45pm
Wed Oct 2, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar?event_id=71978&include_contexts=course_38941)	1pm to 2:45pm
Fri Oct 4, 2024	🗨 **A4 - Journal Discussion on M4** (https://canvas.duke.edu/courses/38941/assignments/162671)	due by 11:59pm
Mon Oct 7, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar?event_id=71979&include_contexts=course_38941)	1pm to 2:45pm
Wed Oct 9, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar?event_id=71980&include_contexts=course_38941)	1pm to 2:45pm
Fri Oct 11, 2024	📝 **A5 - Distributed Generation - Small Hydro Dispatch Model** (https://canvas.duke.edu/courses/38941/assignments/164354)	due by 11:59pm
Mon Oct 14, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar?event_id=71981&include_contexts=course_38941)	1pm to 2:45pm

Wed Oct 16, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar? event_id=71982&include_contexts=course_38941)	1pm to 2:45pm
Fri Oct 18, 2024	📝 **Final Project - Proposal** (https://canvas.duke.edu/courses/38941/assignments/167604)	due by 11:59pm
Mon Oct 21, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar? event_id=71983&include_contexts=course_38941)	1pm to 2:45pm
Wed Oct 23, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar? event_id=71984&include_contexts=course_38941)	1pm to 2:45pm
Fri Oct 25, 2024	📝 **A6 - PV + Storage Management System** (https://canvas.duke.edu/courses/38941/assignments/169068)	due by 11:59pm
Mon Oct 28, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar? event_id=71985&include_contexts=course_38941)	1pm to 2:45pm
Wed Oct 30, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar? event_id=71986&include_contexts=course_38941)	1pm to 2:45pm
Fri Nov 1, 2024	📨 **A7 - Journal Discussion on M7** (https://canvas.duke.edu/courses/38941/assignments/172836)	due by 11:59pm
Mon Nov 4, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar? event_id=71987&include_contexts=course_38941)	1pm to 2:45pm
Wed Nov 6, 2024	📅 **Special Topics in Energy | ENVIRON/ENERGY 590.05.Fa24** (https://canvas.duke.edu/calendar?	1pm to 2:45pm

Fri Nov 8, 2024	📝 **A8 - DEA for Operational Expenditure** **(https://canvas.duke.edu/courses/38941/assignments/175231)**	due by 11:59pm
Mon Nov 11, 2024	📅 **Special Topics in Energy	ENVIRON/ENERGY 590.05.Fa24** **(https://canvas.duke.edu/calendar? event_id=71989&include_contexts=course_38941)**	1pm to 2:45pm
Wed Nov 13, 2024	📅 **Special Topics in Energy	ENVIRON/ENERGY 590.05.Fa24** **(https://canvas.duke.edu/calendar? event_id=71990&include_contexts=course_38941)**	1pm to 2:45pm
Mon Nov 18, 2024	📅 **Special Topics in Energy	ENVIRON/ENERGY 590.05.Fa24** **(https://canvas.duke.edu/calendar? event_id=71991&include_contexts=course_38941)**	1pm to 2:45pm
Wed Nov 20, 2024	📅 **Special Topics in Energy	ENVIRON/ENERGY 590.05.Fa24** **(https://canvas.duke.edu/calendar? event_id=71992&include_contexts=course_38941)**	1pm to 2:45pm
Mon Nov 25, 2024	📅 **Special Topics in Energy	ENVIRON/ENERGY 590.05.Fa24** **(https://canvas.duke.edu/calendar? event_id=71993&include_contexts=course_38941)**	1pm to 2:45pm
Tue Nov 26, 2024	📝 **Final Project - Presentation** **(https://canvas.duke.edu/courses/38941/assignments/179959)**	due by 11:59pm

Class hours: MW 1:25 to 2:40 pm (Gross Hall 100C or **Zoom link** ↪
(https://duke.zoom.us/j/98309226745?
pwd=qADkbZdseRZyD2VUgQQ8mFgSBnDTtO.1))
Instructor: Luana Lima (**luana.marangon.lima@duke.edu**
(mailto:luana.marangon.lima@duke.edu))
            OH: Wed 12:15-13:15pm (Gross Hall 102K or **Luana's**
Zoom (https://duke.zoom.us/my/luanalima)), or by appointment.
TA: Marcio Ribeiro (**marcio.ribeiro@duke.edu**
(mailto:marcio.ribeiro@duke.edu))
            OH: Mondays 10:00 - 12:00 (Grainger Hall 3120)

Course Schedule

| **Syllabus (https://canvas.duke.edu/courses/38941/assignments/syllabus)** | **Assignments**
Schedule (https://canvas.duke.edu/courses/38941/pages/assignments-schedule) | **Journal Pairings**
(https://canvas.duke.edu/courses/38941/pages/journal-pairings) | **Slack** ↪ **(http://env590-**
f24.slack.com) | **Final Project Instructions (https://canvas.duke.edu/courses/38941/pages/final-**
project-instructions) |

Lecture	Module	Date	
L1	**M0 (https://canvas.duke.edu/courses/38941/modules/52051)**	Aug 26	Introductions and Course Ove
L2	**M1 (https://canvas.duke.edu/courses/38941/pages/m1-intro-to-smart-grids)**	Aug 28	Review of Electric Power Syst "Old" Grids and Its Problems, Introduction to Smart Grids or Opportunities and Challenges
-		Sep	**Labor Day no classes**

			2
L3	**M2 (https://canvas.duke.edu/courses/38941/pages/m2-smart-grids-electricity-distribution)**	Sep 4	Introduction to Smart Grids or Smart Grid from Global Perspe
L4		Sep 9	Smart-meter deployment ICT Perspectives, End user vie
L5	-	Sep 11	**Class Discussion on J1 (http wrap=1)** ↓ (https://canvas.duk download_frd=1)
L6	**M3 (https://canvas.duke.edu/courses/38941/modules/59657)**	Sep 16	Finish class discussion on J1 a Smart Grid from Global Perspe Paradigm shift, renewable ene
L7		Sep 18	Distributed generation: definiti Case Study: Rooftop PV study
L8	-	Sep 23	**Class Discussion on J2 (http wrap=1)** ↓ (https://canvas.duk download_frd=1)
L9	**M4 (https://canvas.duke.edu/courses/38941/modules/61539)**	Sep 25	Challenges of DG Integration f DG Optimization: Siting, Sizing Solar Penetration Outlook and
L10		Sep 30	Finish M4 - Solutions to Duck Distributed Energy Resources

	M5 (https://canvas.duke.edu/courses/38941/pages/m5-distributed-energy-resources)		Economics of Energy Storage Energy Storage Applications t
L11		Oct 2	Energy Systems Management Linear Models in R using "lpso
L12	M6 (https://canvas.duke.edu/courses/38941/pages/m6-btm-pv-+-storage-management)	Oct 7	Energy Storage Management Study case: storage managem
L13		Oct 9	Study case: storage managem
-	-	Oct 14	**Fall break no classes**
L14	-	Oct 16	Class Project, Team building,
L15	M7 (https://canvas.duke.edu/courses/38941/modules/65141)	Oct 21	Finish Project Proposal preser Intro to Stochastic Optimizatio Dispatch Models under Uncer
L16		Oct 23	Examples of Stochastic Optim BTM Solar + Storage ⤴ (https://colab.research.google.c usp=sharing) Example 1 and 2 from M7 sli (https://colab.research.google.c usp=sharing)
L17	M8 (https://canvas.duke.edu/courses/38941/pages/m8-transmission-and-distribution-network-pricing-	Oct 28	Intro to Network Pricing - Tran Electricity Rate Structure

	economic-regulation-and-revenue-structure)		Revenue Requirement (CAPE
L18		Oct 30	How to calculate efficient oper DEA Model for utility benchma
L19	M9 (https://canvas.duke.edu/courses/38941/pages/m9-utility-operational-expenditure)	Nov 4	More on DEA - constant vs va Applications of the DEA Mode DEA case study
L20		Nov 6	Cost allocation: Principles and
L21	M10 (https://canvas.duke.edu/courses/38941/pages/m10-cost-allocation)	Nov 11	Cost allocation: Fixed & Incren Cost allocation: Case Study 6- Final Project Presentation Ord
L22	-	Nov 13	**Energy Week Conference - r** Attend a panel as part of the 2 Please register here.
L23	-	Nov 18	Guest Speaker: **Jeffrey Hugh** **74b58912/)** , Utilities Commissi Pre reading (or at least "pre so • State Carbon Plan - recent • F**irst reaction** ⇗ **(https://e** **north-carolina-regulators-ac** **carbon/)** to the plan
L24	-	Nov 20	**Course Evaluation (https://ca** **evaluation)** **Final Project Presentations** **Presentation Schedule (https**