ELEC ENG 4PR4
Net-Zero Emissions Power Systems

COURSE OUTLINE

Please refer to the course website for updated information.

COURSE DESCRIPTION

The course focuses on the enabling technologies for reaching net-zero emissions in the electricity sector. These include renewable energy systems, storage systems, and multi-source energy systems. The course explains the sizing and modeling of these technologies and presents real-world examples. Finally, the course discusses power and energy management and future trends in controlling electrical power systems.

PREREQUISITES AND ANTI-REQUISITES

Prerequisite (s): Registration in any Computer Engineering or Electrical Engineering Program, ELECENG 3CL4, ELECENG 3PI4, and ELECENG 4PK4.

Anti-requisite(s): None.

SCHEDULE and MODE OF DELIVERY

The material for this course will be delivered through a mixture of online videos, textbook readings, live online lectures and tutorials (which are also recorded), and virtualized laboratories. Each component will use Microsoft Teams. At certain points in the course, it may be appropriate to modify the schedule or the platform. The instructor reserves the right to change course elements and will notify students accordingly.

Lecture: Monday and Thursday, 9:30 am – 10:20 am, and Tuesday, 10:30 am – 11:20 am. For some topics, recorded videos are available on MS Teams. Some lectures might be hosted live on MS Teams; they will be announced in advance.

Tutorial: Wednesday 12:30 pm – 1:20 pm for Q&A, discussion, and solving assignments.

Lab: Students do not need to come to the lab room unless they have a TA appointment. Students will self-organize into lab groups of 2 or 3. Members of the same lab group may be in different lab sections. Each lab group will complete and submit a single lab report. For the lab schedule, refer to Mosaic.

INSTRUCTOR

Dr. Babak Nahid-Mobarakeh
E-mail: babak.nahid@mcmaster.ca
Office: ITB-A109
Office Hours: By appointment – see course website for details

TEACHING ASSISTANTS

Names, contact information, and office hours are available on the course website.

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

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

- Understand the net-zero emissions goal and its application to the electricity sector.
- Size renewable energy systems: wind turbines, photovoltaics, solar thermal, hydroelectric, biomass, and geothermal systems.
- Model and control renewable energy systems.
- Understand why and where energy storage is required.
- Size energy storage systems: electrical, mechanical, chemical, and thermal.
- Understand multi-source energy systems: combined heat and power, combined hydrogen and power, and other multi-source configurations.
- Model and control energy converters: electrical-electrical, electrical-thermal, and electrical-hydrogen.
- Formulate and solve energy management problems in multi-source energy systems: resilience, loss, and cost minimization, and multi-scale dynamics.

CEAB GRADUATE ATTRIBUTES (GAS)

Note: The CEAB Graduate Attributes (GAs) defined in this section are measured throughout the course and form part of the Department's continuous improvement process. They are a key component of the accreditation process for the program and will not be taken into consideration in determining a student's actual grade in the course. For more information on accreditation, please ask your instructor or visit: http://www.engineerscanada.ca

Attributes	Indicators		Measurement Method(s)
	Number	Description	
Competence in Specialized Engineering Knowledge.	1.4	Knowledge Base for Engineering	Labs., assignments and exams
Defines the problem by identifying relevant context, constraints, and prior approaches before exploring potential design solutions.	4.1	Investigation	Labs., assignments and exams
Evaluates engineering tools, identifies their limitations, and selects, adapts, or extends them appropriately	5.1	Use of Engineering Tools	Labs., assignments and exams
Evaluates the environmental impact of engineering activities, identifies uncertainties in decisions, and promotes sustainable design	9.1	Professionalism	Labs., assignments and exams
Applies economic principles in decision making	11.1	Ethics and Equity	Labs., assignments and exams

ASSUMED KNOWLEDGE

Mathematics: Linear algebra, Ordinary differential equations, Complex numbers, Laplace transform.

Electrical Engineering: Kirchhoff's circuit laws, Circuits and systems, Lenz's and Faraday's laws, Single-phase and three-phase systems, Transformers, AC generators, Linear control systems, Frequency-domain analysis tools, Stability of dynamic systems, Electrical power systems, electric machines, static power converters.

COURSE MATERIALS

There is no required textbook for this course. There is no single textbook that covers all the course content.

Recommended Textbook

Amin Mirkouei, "Net-Zero and Low Carbon Solutions for the Energy Sector: A Guide to Decarbonization Technologies," Wiley, ISBN: 978-1-119-98216-6, 2024.

Recommended Readings

- Hsing-Hao Wu, Wan-Yu Liu, Michael C. Huang, “Moving Toward Net-Zero Carbon Society: Challenges and Opportunities,” Springer, Open Access, ISBN 978-3-031-24544-2, 2023.
- Jeffrey Rissman, “Zero-Carbon Industry: Transformative Technologies and Policies to Achieve Sustainable Prosperity,” Columbia University Press, ISBN: 9780231204200, 2024.
- Sandeep Dhundhara, Yajvender Pal Verma, “Energy Storage for Modern Power System Operations,” Wiley, ISBN: 978-1-119-76028-3, 2021.
- William D. Fletcher, Craig B. Smith, “Reaching Net Zero: What It Takes to Solve the Global Climate Crisis,” Elsevier, ISBN: 978-0-12-823366-5, 2020.

Lab-at-Home Tools:
Software: MATLAB-Simulink (McMaster campus-wide license).

Calculator:
Only the McMaster Standard Calculator (Casio fx-991 MS or MS Plus) is permitted in tests and examinations. This is available at the Campus Store.

Other:
Lecture notes, lab manuals, and online videos.

COURSE OVERVIEW

Week	Topic	Readings
1	Review and Introduction	Lecture notes, textbooks, and papers.
1	Introduction to Net-Zero Emissions Power Syst. (Topic 1)	Lecture notes, textbooks, and papers.
2	PV Generators (Topic 2)	Lecture notes, textbooks, and papers.
3–4	Power Quality and Control (Topic 3)	Lecture notes, textbooks, and papers.
5–6	Wind Turbine Generators (Topic 4)	Lecture notes, textbooks, and papers.
7–10	Energy Storage Systems (Topic 5)	Lecture notes, textbooks, and papers.
11–12	Multi-Source Energy Systems (Topic 6)	Lecture notes, textbooks, and papers.
13	Future Trends	Lecture notes, textbooks, and papers.

A more detailed timeline is available on the course website.
At certain points in the course, it may make good sense to modify the schedule. The instructor may modify course elements and will notify students accordingly (in class or on the course website).

LABORATORY OVERVIEW

Labs begin in week 3.

Lab	Week	Topic
1	3–4	Introduction to Simulation Software (no assessment)
2	5–6	MPPT Control of a PV Generator
	7	Troubleshooting
3	8–9	Grid-Connected PV Generator
4	10–11	Wind Turbine Generator
5	12–13	Storage System for a Standalone Renewable Energy System (no assessment)

Students do not need to come to the lab room unless they have a TA appointment. Students will self-organize into lab groups of 2 or 3. Members of the same lab group may be in different lab sections. Each lab group will complete and submit a single lab report.

LABORATORY OPERATION

- Each student in the course is required to pass the lab safety quiz prior to attempting any of the laboratories. The quiz will be available on Avenue to Learn.
- Access to all labs is restricted in the interest of security and safety. Information on accessing and using the lab can be found on this webpage: https://www.eng.mcmaster.ca/ece/labs-and-health-safety#Labs-Access-and-Use
- Lab Experiments: Labs will be conducted in groups of 2 or 3 students. If you want to perform the lab individually, you must obtain the instructor's permission.
- Lab Requirements: Students must submit their experiment results on Avenue to Learn by the due date specified in the lab manual. Each group must submit one report. Late submissions will not be accepted. If an MSAF is approved, the weight of a missed report will be transferred to the final exam.

ASSESSMENT

Component	Weight
Labs (3 reports, 5% each)	15 %
Assignments (5 assignments, 3% each)	15 %
Midterm Exam (1)	20 %
Final Exam (1)	50 %
Total	100 %

Grading and Evaluation Policies:

- There are five (5) assignments, three (3) labs, one (1) midterm exam, and one (1) final exam to be evaluated in this course.
- Students must submit their assignments and lab reports on Avenue to Learn by the due date. Late submissions will not be accepted.
- No makeup midterm exam will be granted.

- If an MSAF is approved for any assignments, lab reports, or the midterm exam, its weight will be transferred to the final exam.
- Use of books, notes, other copied materials, computers, and other calculators during exams is subject to the instructor's approval.
- Use of cell phones and online communication tools is not allowed during the exams.
- Any AI-generated content (including text, figures, images, and code) must be disclosed in a section titled "Acknowledgments." You must identify the specific AI system used, specify which sections of the work contain AI-generated content, and provide a brief explanation of how and to what extent the AI was used. This rule applies even if you use AI solely for grammar, tone, or formatting enhancements to human-written text.

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty. Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/
The following illustrates only three forms of academic dishonesty:
• plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
• improper collaboration in group work.
• copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.
Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.
The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the “Code”). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online. It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations.

Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory and online https://hr.mcmaster.ca/app/uploads/2019/07/2019-McMaster-Lab-Manual.pdf

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following whether conducting lab work at school or at home:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.
9. Personal ergonomics should be practiced when conducting lab work. https://bit.ly/3fOE71E
10. Current University health and safety issues, and protocol should be known. https://hr.mcmaster.ca/resources/covid19/workplace-health-and-safety-guidance-during-covid-19/

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
Main Lobby of ITB or
dial “88” after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (On Campus Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.
Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In power labs, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol For Safe Laboratory Practice

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Chair	Shahram Shirani- ITB A111	shirani@mcmaster.ca
ECE Administrator	Shelby Gaudrault- ITB A111	gaudraus@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	