Toronto Metropolitan University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Outline (W2024)

ELE806: Alternative Energy Systems

Instructor(s)	Dr. David Xu [Coordinator] Office: ENG320 Phone: (416) 979-5000 x 556075 Email: dxu@torontomu.ca Office Hours: Wednesday 3-5PM
Calendar Description	The topics include introduction to alternative energy systems, power converters for renewable energies, wind energy system fundamentals, wind generators, doubly fed induction generator based wind turbines, synchronous generator based wind generation systems, control schemes, transient and steady-state analysis, solar energy systems, photovoltaic arrays, and maximum power point tracking schemes. Other alternative energy systems will also be introduced.
Prerequisites	ELE 747
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	1. Power Conversion and Control of Wind Energy Systems, B. Wu, Y. Lang, N. Zargari, and S. Kouro, Wiley-IEEE Press, 480 pages, 2011, ISBN 978-0- 470-59365- 3 2. ELE806 Course Notes: Available on D2L 3. ELE806 Laboratory Manuals: Available on D2L
Reference Text(s):	
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Use specialized core knowledge of power electronics, electric machines, and control theory to understand and design 1) a wind energy conversion system using squirrel induction generator, doubly-fed induction generator, or synchronous generator, and 2) a photovoltaic (PV) energy conversion system with maximum power point tracking (MPPT) control. (**1d**) 2. Generate solutions for the design of PWM switching schemes, grid-side power factor compensation, PI compensator, maximum power point tracking (MPPT), and control schemes for various wind and solar energy systems with a give set of design requirements. (**4b**) 3. Use of MATLAB/SIMULINK tool extensively to Investigate and solve complex problems in wind and solar energy systems, including analysis and modeling of fixed and variable-speed wind energy systems and solar energy systems with partial shading problems. (**5a**) 4. Use the engineering knowledge and consider the environmental factors in the solutions. The measures include the impacts of renewable energy systems to the society and sustainable development. (**9a**) **NOTE:***Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).*

Course Organization	3.0 hours of lecture per week for 13 weeks 1.0 hours of lab per week for 12 weeks 0.0 hours of tutorial per week for 12 weeks
Teaching Assistants	TBA
Course Evaluation	

Theory	
Midterm	25 %
Final Exam	45 %
Laboratory	
Laboratory: 6 Labs 5% Each	30 %
TOTAL:	100 %

Note: In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both **"Theory and Laboratory"** components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the **"Course Evaluation"** section above for details on the Theory and Laboratory components (if applicable).

Examinations	Midterm exam is scheduled for the #7 week (3 Hrs duration), closed book with a formula sheet (covers Weeks 1-6 of lecture and laboratory material) Final Exam, during exam period, 3 hours, closed book with a formula sheet (covers Weeks 8-13 of lecture and rest of laboratory material).
Other Evaluation Information	NOTE: To achieve a passing grade, student must pass both the theory and laboratory components. Laboratory Lab experiments are to be done in partners and the write-ups are handed to your TA during the scheduled lab time as indicated on the course content schedule.
Other Information	None

Course Content

Week	Hours	Chapters / Section	Topic, description
1	3		State-of- the-art wind energy systems wind turbine technology wind energy conversion fixed-speed and variable-speed wind energy systems grid codes

			power factor compensation. (Chapters 1 textbook)
2	3		Wind turbine components turbine power characteristics turbine modeling passive and active stall controls pitch control tip speed ratio maximum power point tracking schemes. (Chapters 2 textbook)
3	3		Reference frame transformation induction generators (IG) IG dynamic and steady state models synchronous generators (SG) SG dynamic and steady state models transient and steady state analysis of wind generators. (Chapters 3 textbook)
4	3		AC voltage controllers multi-channel interleaved boost converters voltage source converters control of grid-tied converters reactive power control. (Chapter 4 textbook)
5	3		System configurations operating principle of fixed-speed IG WECS soft starter reactive power compensation. (Chapter 6 textbook)
6	3		System configuration direct field oriented control (FOC) rotor flux identification system dynamic analysis steady state calculations. (Chapter 7 textbook)
7	3		Midterm
8	2		System configuration zero d-axis current (ZDC) control maximum torque per ampere (MTPA) control unit power factor (UPF) control transient and steady state analysis. (Chapter 9 textbook)
9	3		System configurations super- and sub-synchronous modes of operation stator voltage oriented control (SVOC) (Chapter 8 textbook)
10	3		DFIG dynamic and steady state models system dynamic and steady state analysis. (Chapter 8 textbook)

11	3		Photovoltaic (PV) arrays PV cell modeling partial shading effect standalone and grid-tied PV systems;
12	3		PV power converter systems maximum power point tracking (MPPT) schemes. (Course Notes posted on D2L)
13	3		Introduction to tidal and wave energy systems.

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2-3	Lab 1	Lab 1 - Modeling and Simulation of Fixed-Speed Wind Turbines - Implement the fixed-speed wind turbine model for induction generator based WECS - Study the power and torque curves for wind turbine and - Investigate the pitch angle control system.
4-5	Lab 2	Lab 2 - Modeling and Simulation of Induction Generators - Implement the squirrel-cage induction generator (SCIG) in arbitrary reference frame - Investigate the dynamic response of SCIG with direct grid connection and - Compare the response of SCIG model with Sim-Power-Systems model.
6-7	Lab 3	Lab 3 - Decoupled Voltage Oriented Control of Grid-Tied Inverters - Understand the principle of VOC with a decoupling controller for grid-tied inverter - Design the sinusoidal pulse width modulation scheme for grid-tied inverter and - Investigate the active and reactive power control with the grid-tied inverter.
8-9	Lab 4	Lab 4 - Fixed-Speed Induction Generator based WECS - Implement the fixed-speed squirrel-cage induction generator based WECS - Investigate the dynamic response of SCIG WECS with direct grid connection and soft start and - Design and implement reactive power compensation scheme for fixed-speed WECS.
10-11	Lab 5	Lab 5 - Zero d-axis Current (ZDC) Control of PMSG WECS - Design the ZDC control for variable-speed direct-drive non-salient pole PMSG WECS - Design the sinusoidal pulse width modulation scheme for generator-side converter and - Investigate study the dynamic performance of PMSG WECS during start-up.

12-13	Lab 6	Lab 6 â€“ Investigation of Photovoltaic Panel Characteristics - Modeling of PV arrays - Understand the principle of PV array operation and - Understand the temperature and irradiance effect on PV array output

University Policies & Important Information

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the Senate website

Refer to the Departmental FAQ page for furhter information on common questions.

Important Resources Available at Toronto Metropolitan University

- The Library provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the Library's virtual research help service to speak with a librarian.
- Student Life and Learning Support offers group-based and individual help with writing, math, study skills, and transition support, as well as resources and checklists to support students as online learners.

- You can submit an Academic Consideration Request when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website and select the blue radio button on the top right hand side entitled: **Academic Consideration Request (ACR)** to submit this request.

  For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate Policy 167: Academic Consideration.

- If a student is requesting accommodation due to a religious, Aboriginal and/or spiritual observance, they must submit their request via the online Academic Consideration Request (ACR) system **within the first two weeks of the class or, for a final examination, within two weeks of the posting of the examination schedule**. If the required absence occurs within the first two weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these requests should be submitted with as much lead time as possible in advance of the required absence.

- If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The Remote Learning Guide for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
- Information on Copyright for Faculty and students.

Accessibility

- Similar to an accessibility statement, use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about Academic Accommodation Support.
- Learn how to register with AAS.

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about Academic Accommodations versus Academic Consideration and how to access each.

Wellbeing Support

At Toronto Metropolitan University, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line:**24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk:**24/7-hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via My SSP app or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email csdc@torontomu.ca
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the Toronto Metropolitan University Mental Health and Wellbeing website.