

Course Outline (W2023)

ELE806: Alternative Energy Systems

Instructor(s)	Dr. David Xu [Coordinator] Office: ENG320 Phone: (416) 979-5000 x 556075 Email: dxu@torontomu.ca Office Hours: Monday 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):	<ol style="list-style-type: none"> 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)	<p>At the end of this course, the successful student will be able to:</p> <ol style="list-style-type: none"> 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) <p>NOTE:Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).</p>

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	Amir Reza Nikzad Ghadikolaei, E-mail: amirreza.nikzad@ryerson.ca												
Course Evaluation	<table border="1"> <thead> <tr> <th colspan="2">Theory</th> </tr> </thead> <tbody> <tr> <td>Midterm</td> <td>25 %</td> </tr> <tr> <td>Final Exam</td> <td>45 %</td> </tr> <tr> <th colspan="2">Laboratory</th> </tr> <tr> <td>Laboratory: 6 Labs 5% Each</td> <td>30 %</td> </tr> <tr> <td>TOTAL:</td> <td>100 %</td> </tr> </tbody> </table> <p>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).</p>	Theory		Midterm	25 %	Final Exam	45 %	Laboratory		Laboratory: 6 Labs 5% Each	30 %	TOTAL:	100 %
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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 <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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 – 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
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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](#)

1. In accordance with the Policy on TMU Student E-mail Accounts (Policy 157), Toronto Metropolitan University (TMU) **requires** that any electronic communication by students to TMU faculty or staff be sent from their official university email account;
2. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented;
3. Assignments, projects, reports and other deadline-bound course assessment components handed in past the due date will receive a mark of ZERO, unless otherwise stated. Marking information will be made available at the time when such course assessment components are announced.
4. Familiarize yourself with the tools you will need to use for remote learning. The [Continuity of Learning Guide](#) for students includes guides to completing quizzes or exams in D2L or Respondus, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
5. The University has issued a minimum technology requirement for remote learning. Details can be found at: <https://torontomu.ca/covid-19/students/minimum-technology-requirements-remote-learning>. Please ensure you meet the minimum technology requirements as specified in the above link.
6. Toronto Metropolitan University COVID-19 Information and Updates (available <https://www.torontomu.ca/covid-19/students>) for Students summarizes the variety of resources available to students during the pandemic.
7. Refer to our **Departmental FAQ** page for information on common questions and issues at the following link: <https://www.ecb.torontomu.ca/guides/Student.Academic.FAQ.html>.

Missed Classes and/or Evaluations

When possible, students are required to inform their instructors of any situation which arises during the semester which may have an adverse effect upon their academic performance, and must request any consideration and accommodation according to the relevant policies as far in advance as possible. Failure to do so may jeopardize any academic appeals.

1. **Academic Consideration Requests for missed work** (e.g. missing tests, labs, etc) - According to [Senate Policy 134](#), Section 1.2.3, if you miss any exams, quizzes, tests, labs, and/or assignments for health or compassionate reasons you need to inform your instructor(s) (via email whenever possible) in advance when you will be missing an exam, test or assignment deadline. When circumstances do not permit this, you must inform the instructor(s) as soon as reasonably possible". *In the case of illness, a [Toronto Metropolitan Student Health Certificate](#), or a letter on letterhead from an appropriate regulated health professional with the student declaration portion of the Student Health Certificate attached. For reasons other than illness, proper documentation is also required (e.g. death certificate, police report, TTC report). **ALL supporting documentation for illness or compassionate grounds MUST be submitted within three (3) working days of the missed work.** **NOTE: You are required to submit all of your pertinent documentation through the University's online Academic Consideration Request system at the following link: prod.apps.ccs.torontomu.ca/senateapps.***
2. **Religious, Aboriginal and Spiritual observance** - If a student needs accommodation because of religious, Aboriginal or spiritual observance, they must submit a Request for Accommodation of Student Religious, Aboriginal and Spiritual Observance AND an Academic Consideration Request form within the first 2 weeks of the class or, for a final examination, within 2 weeks of the posting of the examination schedule. If the requested absence occurs within the first 2 weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these forms should be submitted with as much lead time as possible in advance of the absence. Both documents are available at www.torontomu.ca/senate/forms/reobservforminstr.pdf. **If you are a full-time or part-time degree student, then you submit the forms to your own program department or school;**
3. **Academic Accommodation Support** - Before the first graded work is due, students registered with the [Academic Accommodation Support office](#) (AAS - prod.apps.ccs.torontomu.ca/senateapps) should provide their instructors with an

Academic Accommodation letter that describes their academic accommodation plan.

Virtual Proctoring Information (if used in this course)

Online exam(s) within this course may use a virtual proctoring system. Please note that your completion of any such virtually proctored exam may be recorded via the virtual platform and subsequently reviewed by your instructor. The virtual proctoring system provides recording of flags where possible indications of suspicious behaviour are identified only. Recordings will be held for a limited period of time in order to ensure academic integrity is maintained and then will be deleted.

Access to a computer that can support remote recording is your responsibility as a student. The computer should have the latest operating system, at a minimum Windows (10, 8, 7) or Mac (OS X 10.10 or higher) and web browser Google Chrome or Mozilla Firefox. You will need to ensure that you can complete the exam using a reliable computer with a webcam and microphone available, as well as a typical high-speed internet connection. Please note that you will be required to show your Toronto Metropolitan University OneCard prior to beginning to write the exam. In cases where you do not have a Toronto Metropolitan University OneCard, government issued ID is permitted.

Information will be provided prior to the exam date by your instructor who may provide an opportunity to test your set-up or provide additional information about online proctoring. Since videos of you and your environment will be recorded while writing the exam, please consider preparing the background (room / walls) so that personal details are not visible, or move to a room that you are comfortable showing on camera.

Academic Integrity

Toronto Metropolitan University's [Policy 60 \(the Academic Integrity policy\)](#) applies to all students at the University. Forms of academic misconduct include plagiarism, cheating, supplying false information to the University, and other acts. The most common form of academic misconduct is plagiarism - a serious academic offence, with potentially severe penalties and other consequences. It is expected, therefore, that all examinations and work submitted for evaluation and course credit will be the product of each student's individual effort (or an authorized group of students). Submitting the same work for credit to more than one course, without instructor approval, can also be considered a form of plagiarism.

Suspensions of academic misconduct may be referred to the Academic Integrity Office (AIO). Students who are found to have committed academic misconduct will have a Disciplinary Notation (DN) placed on their academic record (not on their transcript) and will normally be assigned one or more of the following penalties:

1. A grade reduction for the work, ranging up to and including a zero on the work (minimum penalty for graduate work is a zero on the work);
2. A grade reduction in the course greater than a zero on the work. (Note that this penalty can only be applied to course components worth 10% or less, and any additional penalty cannot exceed 10% of the final course grade. Students must be given prior notice that such a penalty will be assigned (e.g. in the course outline or on the assignment handout);
3. An F in the course;
4. More serious penalties up to and including expulsion from the University.

The unauthorized use of intellectual property of others, including your professor, for distribution, sale, or profit is expressly prohibited, in accordance with Policy 60 (Sections 2.8 and 2.10). Intellectual property includes, but is not limited to:

1. Slides
2. Lecture notes
3. Presentation materials used in and outside of class
4. Lab manuals
5. Course packs
6. Exams

For more detailed information on these issues, please refer to the [Academic Integrity policy](#) (<https://www.torontomu.ca/senate/policies/pol60.pdf>) and to the Academic Integrity Office website (<https://www.torontomu.ca/academicintegrity>).

Academic Accommodation Support

Toronto Metropolitan University acknowledges that students have diverse learning styles and a variety of academic needs. If you have a diagnosed disability that impacts your academic experience, connect with Academic Accommodation Support (AAS). Visit the [AAS website](#) or contact asadmin@torontomu.ca for more information.

Note: All communication with AAS is voluntary and confidential, and will not appear on your transcript.

Important Resources Available at Toronto Metropolitan University

1. [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 at <https://library.torontomu.ca/ask> to speak with a librarian.
2. [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](#).
3. 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 radial button on the top right hand side entitled: Academic Consideration Request (ACR) to submit this request).

Please note that the Provost/Vice President Academic and Deans approved a COVID-19 statement for Fall 2022 related to academic consideration. This statement will be built into the Online Academic Consideration System and will also be on the [Senate website \(www.torontomu.ca/senate\)](http://www.torontomu.ca/senate) in time for the Fall term:

Policy 167: Academic Consideration for Fall 2022 due to COVID-19: Students who miss an assessment due to cold or flu-like symptoms, or due to self-isolation, are required to provide a health certificate. All absences must follow Senate [Policy 167: Academic Consideration](#).

Also NOTE: Policy 167: Academic Consideration does allow for a once per term academic consideration request without supporting documentation if the absence is less than 3 days in duration and is **not for a final exam/final assessment**. If the absence is more than 3 days in duration and/or is for a final exam/final assessment, documentation is required. For more information please see Senate [Policy 167: Academic Consideration](#).

4. [TMU COVID-19 Information and Updates for Students](#) summarizes the variety of resources available to students during the pandemic.
5. [TMU COVID-19 Vaccination Policy](#).
6. 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.
7. Information on Copyright for [students](#).
8. At Toronto Metropolitan University (TMU), 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:

- o **Distress Line:** 24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- o **Good2Talk:** 24/7 hour line for postsecondary students (phone: 1-866-925-5454)
- o **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: 553596 or email osvse@torontomu.ca

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](#).