Course Outline

Instructor	**Prof. Jean Duquette**
Contact information	Room: ME 3148 Tel: ext. 4183 Email: jean.duquette@carleton.ca
Office hours	Tuesdays and Thursdays from 11:35 am to 12:30 pm (*Note: Instructor office hours are held online during the scheduled lecture periods*)

Lecture schedule	Online: pre-recorded lectures will be made available on the Brightspace course website
Lab schedule (SREE 4001 only)	Online: pre-recorded lab demonstrations will be made available on the Brightspace course website (see lab outline for details)
PA schedule	PA sessions will be held in-person on Mondays from 11:35 am to 2:25 pm in AT 302.
Teaching assistant(s)	TBA

Description

This course examines issues pertaining to the design of our energy system as a whole with a special focus on large-scale power generation. Current trends in fossil fuel utilization in the energy sector and their relation to rising anthropogenic emissions of CO_2 are discussed. Benefits and drawbacks of conventional and bioenergy sources are identified. Thermodynamic energy balances are used to analyze geothermal and solar power plant energy conversion cycles. Additionally, wind, solar PV, and hydro power plants are described and equations are provided for sizing these plants given a set of realistic constraints. The impacts of renewable energy integration on an energy system are examined and the benefits of energy storage are presented. A set of techno-economic assessment tools are provided for evaluating and comparing the various power plants discussed in the course. The course includes an overview of energy networks. The efficient operation of both the electrical grid and district energy grids is reviewed and technologies for coupling these networks are presented.

Learning outcomes

By the end of this course, students will be able to

- Develop a simple energy system architecture model for a given region and use it to locate potential waste streams and/or appropriate sites for energy storage.
- Assess the impacts of power generation on the environment.
- Classify a broad range of power plants and their individual components, and formulate design requirements and constraints for each.

- Apply engineering project analysis tools to assess economic costs and benefits of a broad range of power plants.
- Quantify the impacts of renewable power generation on the energy system and use probabilistic tools to account for the intermittency of non-dispatchable generation.
- Size electrical and thermal energy storage systems given a set of realistic constraints.
- Size the main components of a district energy grid and appreciate the importance of coupling electrical and thermal networks for improving energy system efficiency.
- Design and size a variety of power plants at the pre-feasibility stage including thermal, wind, solar, and geothermal plants.

Format

SREE 4001: Lectures three hours per week, labs (see lab outline for details), problem analysis, design project
MECH 4403 Lectures three hours per week, problem analysis, design project

- The problem analysis (PA) component of the course gives students the opportunity to work together on the assigned problem sets (*i.e.* PA1 – PA7). These problem sets are designed to help students learn and apply the content taught in the course. As they are not graded, it is the student's responsibility to work through the problems and gain an understanding of the course content. As the midterm and final exam are largely based on the problem sets, it is highly recommended that students complete them.
- Students in both SREE 4001 and MECH 4403 are additionally required to complete a design project (see project outline for details).

Assessment

The course grading scheme is broken down as follows by component:

Course component	**MECH 4403**	**SREE 4001**
Design project	20%	20%
Labs	-	15%
Midterm exam (a formula sheet will be provided to students by the instructor)	20%	15%
Final exam (a formula sheet will be provided to students by the instructor)	60%	50%

***** You must pass the final exam in order to pass this course *****

Expectations

All student deliverables such as the lab reports, design project reports and presentations are expected to be clear and concise, professional looking/sounding, and complete (*i.e.* deliverables must include all required sections). Missed sections, poor grammar, poor appearance/preparation will result in lost marks. *Students are expected to strictly adhere to course submission deadlines for all deliverables. Penalties will be incurred for late submissions (very late submissions will not be marked).*

Schedule

				Deliverables		
Week	**Topics**	**Date**		**Posted / Scheduled**	**Due**	**Notes**
	Module 1: Energy and Society					
1		09-07	T			No class
	Course intro (instructor, outline, design project, labs), socioeconomic considerations, energy consumption, CO_2 emissions	09-09	Th	Course-outline, DP-outline, L-outline and manuals		
2-	Climate change, energy policy mechanisms for combatting climate change, energy system architecture model Fossil fuels, resource utilization, GHG reduction options, energy return on energy invested	09-14	T			Select DP groups
		09-16	Th	PA1		Present PA1
		09-21	T	L-E1_demo		Assign DP topics to groups
	Module 2: Energy System Analysis, Part 1 – Intermittent Generation					
-3	Solar PV power	09-23	Th	PA2		Present PA2
4	Wind power, off-shore power	09-28	T		DP-R1	
		09-30	Th	Sol-PA1, PA3		Discuss Sol-PA1, Present PA3
5	Run-of-river hydro power, the electrical grid	10-05	T	L-E2_demo	L-R1	
		10-07	Th	Sol-PA2, PA4		Discuss Sol-PA2, Present PA4
6	Impacts of intermittency on the electrical grid, electrical energy storage,	10-12	T			
		10-14	Th	Sol-PA3, Sol-PA4, PA5, Midterm exam formula sheet		Discuss Sol-PA3 & PA4, Present PA5
7	Thermal grids, **MIDTERM EXAM** *(Note: Midterm will be held online on October 21st from 11:35 am – 12:55 pm) Exam covers everything taught until October 15th, and includes material from PA1 – PA4)*	10-19	T	L-E3_demo	L-R2	
		10-21	Th	PA6	DP-R2	Present PA6
8						Fall break

9-	Thermal energy storage, economic valuation methods, financial metrics	11-02	T			
	Module 3: Energy Plant Economics					
-10	Levelized electricity cost, cost escalation, capitalized cost, power plant costs, power plant emissions, subsidies, externalities, life cycle analysis comparison	11-04	Th	Sol-PA5		Discuss Sol-PA5
		11-09	T	L-E4_demo	L-R3	
		11-11	Th	Sol-PA6, PA7		Discuss Sol-PA6, Present PA7
	Module 4: Energy System Analysis, Part 2 - Dispatchable Generation					
11	Thermal power plants, power generation from low temperature thermal sources	11-16	T			
		11-18	Th	DP-R3, final presentation schedule		
12	Nuclear fission, nuclear fusion and beyond	11-23	T		L-R4	
		11-25	Th	Sol-PA7	DP-R4 (slides)	Discuss Sol-PA7
	Design Project Presentations and Final Review					
13	Group design project presentations	11-30	T			
		12-02	Th	Final exam formula sheet		
14	Group design project presentations, Final exam review	12-07	T			
		12-09	Th		DP-R3, DP-R5	Discuss final exam

***Table legend**: Tuesday (T), Thursday (Th), Lab (L), Solutions (Sol), Problem analysis handout (PA), Design project (DP), Experiment (E), Report (R)*

Note: All deliverables are due at 11:59 pm on the days indicated in the schedule

Textbook

No textbook is required. References to additional learning resources will be provided throughout the course.

Website

Course materials (*i.e.* lecture slides & notes, lab procedures, problem sets & solutions, design project guidelines, and supplemental materials), and grades will be posted on the Brightspace course website. Students are expected to check the website regularly throughout the duration of the course for updates, cancellations, etc....

Policies

- Academic integrity:

Although integrity and honesty is the expectation, students found guilty of plagiarism and/or cheating will be dealt with according to Carleton University's academic integrity policy (https://carleton.ca/registrar/academic-integrity/)

- Student-Instructor email communication:

To receive an email response from the instructor, messages must be sent from either a valid "MyCarleton" account or via the "Brightspace" platform. Please write "MECH 4403" or "SREE 4001" in the subject line. Please allow up to two business days for the instructor to respond. Answers regarding in-depth technical questions will only be given orally during scheduled office hours (not by email).

- Electronics (not applicable for online pre-recorded lectures):

The use of laptops, surfaces, and smartphones is encouraged during lectures and problem analysis sessions for purposes of note-taking and research (granted the volume is turned off). Please refrain from using these devices for other non-course related activities (*e.g.* movies, gaming, social media, etc…) as they can be distracting to other students in the class and impede their ability to learn.

- Course deliverables:

Students are expected to keep personal copies of all deliverables submitted during the course.

- Labs (SREE 4001 only):

Laboratory demonstrations are pre-recorded and posted on the Brightspace course website. It is the student's responsibility to watch the demonstrations and complete the lab reports on-time as per the guidelines provided. Students failing to submit one or more lab reports will receive a grade of **F** for the course (except under exceptional circumstances such as illness or bereavement – documentation is required).

- Deferred term work:

Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor and for making alternate arrangements (no later than three working days after the term work was due). In all cases, formative evaluations providing feedback to the student should be replaced with formative evaluations.

- Missed midterm exam:

Students are expected to write the midterm exam on the day it is scheduled. Due to the challenges associated with online exams, no accommodations will be given with regards to shifting the exam to an earlier or later time. **It should be noted that the final exam will be significantly more challenging than the midterm exam**.

- Missed final exam:

If a student misses the final exam, they must contact the appropriate office at the registrar within the time period specified in the current undergraduate calendar. University guidelines will be followed to deal with the situation.

- Requests for academic accommodation (taken from Carleton Central):

You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows:

Pregnancy obligation
Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit the Equity Services website: carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf

Religious obligation
Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit the Equity Services website: carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf

Academic Accommodations for Students with Disabilities
If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. carleton.ca/pmc

Survivors of Sexual Violence
As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and is survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: carleton.ca/sexual-violence-support

Accommodation for Student Activities
Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf

For more information on academic accommodation, please contact the departmental administrator or visit: students.carleton.ca/course-outline

COVID-19 measures
All members of the Carleton community are required to follow COVID-19 prevention measures and

all mandatory public health requirements (e.g. wearing a mask, physical distancing, hand hygiene, respiratory and cough etiquette) and mandatory self-screening prior to coming to campus daily.

If you feel ill or exhibit COVID-19 symptoms while on campus or in class, please leave campus immediately, self-isolate, and complete the mandatory symptom reporting tool. For purposes of contact tracing, attendance will be taken in all classes and labs. Participants can check in using posted QR codes through the cuScreen platform where provided. Students who do not have a smartphone will be required to complete a paper process as indicated on the COVID-19 website.

All members of the Carleton community are required to follow guidelines regarding safe movement and seating on campus (e.g. directional arrows, designated entrances and exits, designated seats that maintain physical distancing). In order to avoid congestion, allow all previous occupants to fully vacate a classroom before entering. No food or drinks are permitted in any classrooms or labs.

For the most recent information about Carleton's COVID-19 response and required measures, please see the University's COVID-19 webpage and review the Frequently Asked Questions (FAQs). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca

Please note that failure to comply with University policies and mandatory public health requirements, and endangering the safety of others are considered misconduct under the Student Rights and Responsibilities Policy. Failure to comply with Carleton's COVID-19 procedures may lead to supplementary action involving Campus Safety and/or Student Affairs.