University of Victoria Engineering

Faculty of Engineering

Department of Civil Engineering

COURSE OUTLINE

CIVE 480A/580 – Energy Systems Decarbonization

Term – Summer 2019 (201905)

Instructor	**Office Hours**
Dr. Madeleine McPherson	Days: Tuesday
Phone: 250-472-5083	Time: 12pm- 1pm
E-mail: mmcpherson@uvic.ca	Location: EOW 343

List all prerequisites and co-requisites:
CSC 111 - Fundamentals of programming with engineering applications CIVE 295 - Building Science Fundamentals CIVE 360 - Sustainable transportation systems

LECTURE DATE(S)

Section: A01 / CRN 31638	Days: Tuesdays	Time: 8:30am-11:20pm	Location: ELW B220

TA Name	**E-mail**	**Office**
Cameron Wade	cameron.wade13@gmail.com	EOW 115

Required Text	**Optional Text**
None - I will post copies of all required course readings and materials on the course GitLab repository	
Reference Materials: I will post the reference materials slides on course GitLab repository	

COURSE OBJECTIVES:

Meeting Canada's commitment to the Paris Agreement will require a fundamental shift in our energy system: increased generation from renewable sources, electrification of the transport and building sectors, and planning harmonization across jurisdictions and scales. This course explores the principles of energy systems decarbonization through optimization modelling. We will review a range of systems modelling themes, from data collection to optimization in the context of energy systems, model architecture, and visualizing results while developing or refining their programming (python) skills.

Throughout this course, students will focus on a term-long project in either a group (for students enrolled in CIVE 480A) or individually (for students enrolled in CIVE 580). Each group (CIVE 480A) or student (CIVE 580) will focus on a developing and applying an energy system model. To start the CIVE 480 students off, we have provided eight different toymodels on the GitLab repository for this course:

- Integrated assessment toymodel
- Electricity system capacity expansion toymodel

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- Electricity system dispatch toymodel
- Transport system charger design toymodel
- Transport system EV assignment toymodel
- Individual building toymodel
- District/city-scale energy hub toymodel
- Water system toymodel

Graduate students enrolled in CIVE 580 will be expected to develop a new model from scratch, but are encouraged to refer to the toymodels listed above for inspiration. Throughout the term, students will extend their toymodel their direction of choice: adding additional constraints or complexity to the model, collecting improved data inputs, exploring sensitivities, developing effective visualizations, and so on.

This course is built on the principles of a flipped classroom and problem-based learning. In a flipped classroom, most of the course content is available for students to peruse outside of class time, including papers, videos, and code. In-class time will focus on group work and one-on-one discussions with the TA and instructor. In problem-based learning, students define their project direction and solve problems independently or within their groups; the instructor will not be identifying which specific problems to solve or how to solve them.

LEARNING OUTCOMES: At the end of this course, students will be able to:

- Apply energy systems concepts to decarbonization
- Explain the energy systems modelling landscape
- Understand the modelling and research workflow
- Refine or develop programming skills with python, optimization with pyomo, visualizations with matplotlib and plotly, and code sharing and version control with GitLab
- Apply the principles of systems modelling and optimization
- Develop an effective model framework
- Apply software to inform an energy system problem or question
- Analyze model outputs to develop insights into energy system design and operation
- Evaluate the strengths and weaknesses of assumptions, data, and modelling methods
- Devise and communicate evidence-based conclusions

ASSESSMENTS

Assessment	Deliverable	Weight	Due date	Type
Exercise 1: Assessment	In-class demonstration	None	May 7	Individual
Exercise 2: Assessment Exercise 3: Assessment Exercise 4: Assessment	Nine PowerPoint slides (email to TA)	10%	May 21	Individual
Project Proposal Presentation	In-class presentation	15%	May 28	Group
Exercise 5: Assessment Exercise 6: Assessment Progress Evaluation (PE) #1	Six PowerPoint slides (deliver in PE #1) In-class demonstration	15%	June 11	Group
Exercise 7: Assessment Progress Evaluation (PE) #2	Three PowerPoint slides (deliver in PE #2) In-class demonstration	15%	June 25	Group
Exercise 8: Assessment Progress Evaluation (PE) #3	One PowerPoint slide (deliver in PE #3) In-class demonstration	15%	July 23	Group
Final presentation	In-class presentation	25%	July 30	Group
Peer evaluation	Evaluation (email to TA)	5%	July 30	Individual

Exercise #1 Assessment - Setup computer with modelling software:
- Make sure that your computer is set up such that you have access to and can use each of these software packages
- Clone the course repo onto your machine and ensure that you can run through the exercise and toymodel cells
- Setup a new GitLab project that includes all of your teammates

Exercise #2 Assessment - Background information on energy systems:
In three slides, address the following using the content from this exercise and your research:
- Frame your chosen sector/toymodel in a broader context: why is that sector important to decarbonization?
- Motivate your project: what are the current key areas of interest in your sector?
- Project motivation: what are some of the key challenges for the sector?

Exercise #3 Assessment - Introduction to modelling:
In three slides, address the following using the content from this exercise and your research:
- Explain the focus of your model and work plan (e.g. in terms of the modelling workflow, model type, etc.)
- What are the limitations of your model? What can this type of model do and not do?
- Where do you plan on pursuing additional accuracy versus additional breadth?

Exercise #4 Assessment - Explore project ideas:
In three slides, address the following using the content from this exercise and your research:
- Propose the direction that you would like to take your energy systems modelling work in this semester.
- Defend this proposal with compelling and motivating arguments. Why have you chosen the direction that you did? What other directions did you consider and reject (and why)?
- Develop a work plan (timeline and responsibilities) to achieve your proposal, with a clearly articulated scope: What will you be doing? What won't you be doing? What gaps or limitations will this leave?

Project Proposal Presentation:

In your groups, amalgamate all of the background information (on energy systems and modelling) and project ideas that each of you has come up with individually into one cohesive presentation. Your presentation should cover the following points:
- Articulate the primary (and perhaps secondary) questions or objectives that will drive your work. What questions or problems will your model help to solve? Who could use this information? Why is this important?
- Define a preliminary work plan (e.g. in the form of a Gantt Chart), clearly identifying the responsibility of different teammates in the group.

Each group (for students enrolled in CIVE 480A) or individual (for students enrolled in CIVE 580) will deliver their proposal presentation to the class. Presentations should not exceed 5 minutes and will be followed by 2 minutes of questions, discussion, and feedback. The presentation schedule will be strictly enforced. During the question/discussion period, be sure to listen to feedback from instructors and peers, and think about how you can incorporate this feedback into your planned work. As a listener, you will be expected to ask your peers probing questions and provide your peers with constructive feedback.

Exercise #5 Assessment - Introduction to Python and Pandas:
In three slides, address the following:
- Characterize input data
- Discuss limitations
- Consider improving data input

Exercise #6 Assessment - Introducing optimization with pyomo:
In three slides, define your toymodel in optimization terms:
- Articulate model objective, constraints, inputs & outputs
- What constraints and data are included or excluded? What does this mean for what you can/cannot do with your model?
- What is the overall architecture of your model?

Progress Evaluation #1:
By the first progress evaluation, you should be ready to demonstrate the following:
- The model is functional – you can execute it and get preliminary results
- You have characterized the effectiveness of the framework, and identified the key limitations that you will address
- You have explored the quality of the data input and considered collecting additional or improved data
- You have started to extend your simple model into something that can deliver insightful results
- You have begun to explore the sensitivities of the model to data inputs and model frameworks
- You have begun to explore the types of results that the model produces, and how you would like to improve them

Exercise #7 Assessment - Visualizations:
In three slides, develop three graphs, charts, or visualizations of any type that effectively articulate several key results
- Lay out the key results that you want to communicate with quality visualizations
- Be creative and innovative in your visualizations, such as the kaleidoscope visualization from NREL

Progress Evaluation #2:
By the second progress evaluation, you should be ready to demonstrate the following:
- You have made good progress on extending your simple toy model into something that can deliver insightful results
- You have developed the first iteration of results and know how you will analyze them

- You have begun to brainstorm or develop effective visualizations
- You have developed a scenario matrix that is targeted to the question that you want to work on
- You have started to run scenarios, and refine your scenario matrix accordingly
- You have some preliminary visualizations that are targeted to answering your question

Exercise #8 Assessment - Scenario Matrix:
Assemble your scenario matrix and display it on one slide.

Progress Evaluation #3:
By the third progress evaluation, you should be ready to demonstrate the following:
- You have made significant steps forward in reaching your project objectives
- You should be able to deliver results, analysis, and visualizations
- You have run your model for each scenario in your scenario matrix
- You have begun analyzing the results and have identified any final sensitivities

Final presentation:
In your groups, assemble all of the work that you have completed over the semester: the sectoral context in the energy system, model structure and motivation, data input characterization, scenario matrix, results, visualizations, etc. Each team will present their work in the final class in a 7-minute presentation. You will be evaluated based on:
- the extent to which you have achieved your initial objectives (i.e. addressed your research question or problem)
- the quality of your model, results, and analysis
- the clarity of your presentation (i.e. compelling narrative and effective visualizations)
- the extent to which you have incorporated the course exercises into your project

Peer Assessment:
I expect groups to work together in an inclusive, supportive and collaborative way. Any issues within the group should be discussed with the instructor and TA as soon as possible. Each student will evaluate the others in their group. These peer-evaluations will then be taken into account while assigning individual grades to students.

NOTE:
The final grade obtained from the above marking scheme for the purpose of GPA calculation will be based on the percentage-to-grade point conversion table as listed in the current Undergraduate Calendar.

COURSE LECTURE NOTES

Unless otherwise noted, all course materials supplied to students in this course have been prepared by the instructor and are intended for use in this course only. These materials are NOT to be re-circulated digitally, whether by email or by uploading or copying to websites, or to others not enrolled in this course. Violation of this policy may in some cases constitute a breach of academic integrity as defined in the UVic Calendar.

There will be no examination for this course.

Syllabus statement

A note to remind you to take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone.

Counselling Services - *Counselling Services can help you make the most of your university experience. They offer free professional, confidential, inclusive support to currently registered UVic students.* https://www.uvic.ca/services/counselling/

Health Services - *University Health Services (UHS) provides a full service primary health clinic for students, and coordinates healthy student and campus initiatives.* http://www.uvic.ca/services/health/

Centre for Accessible Learning - *The CAL staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations* https://www.uvic.ca/services/cal/. *The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.*

Elders' Voices - *The Office of Indigenous Academic and Community Engagement (IACE) has the privilege of assembling a group of Elders from local communities to guide students, staff, faculty and administration in Indigenous ways of knowing and being.* *https://www.uvic.ca/services/indigenous/students/programming/elders/index.php*

GENERAL INFORMATION

Note to Students:

Students who have issues with the conduct of the course should discuss them with the instructor first. If these discussions do not resolve the issue, then students should feel free to contact the Chair of the Department by email or the Chair's Secretary to set up an appointment.

"Attendance

Students are expected to attend all classes in which they are enrolled. An academic unit may require a student to withdraw from a course if the student is registered in another course that occurs at the same time….

An instructor may refuse a student admission to a lecture, laboratory, online course discussion or learning activity, tutorial or other learning activity set out in the course outline because of lateness, misconduct, inattention or failure to meet the responsibilities of the course set out in the course outline. Students who neglect their academic work may be assigned a final grade of N or debarred from final examinations.

Students who do not attend classes must not assume that they have been dropped from a course by an academic unit or an instructor. Courses that are not formally dropped will be given a failing grade, students may be required to withdraw and will be required to pay the tuition fee for the course." UVic Calendar, (2019-2020)
http://web.uvic.ca/calendar/undergrad/info/regulations/attendance.html

Accommodation of Religious Observance

The University recognizes its obligation to make reasonable accommodation for students whose observance of holy days might conflict with the academic requirements of a course or program.
Students are permitted to absent themselves from classes, seminars or workshops for the purposes of religious or spiritual observance.
In the case of compulsory classes or course events, students will normally be required to provide reasonable notice to their instructors of their intended absence from the class or event for reasons of religious or spiritual observance. In consultation with the student, the instructor will determine an appropriate means of accommodation. The instructor may choose to reschedule classes or provide individual assistance.
Where a student's participation in a class event is subject to grading, every reasonable effort will be made to allow the student to make up for the missed class through alternative assignments or in subsequent classes. Students who require a rescheduled examination must give reasonable notice to their instructors. If a final exam cannot be rescheduled within the regular exam period, students may request an academic concession.
To avoid scheduling conflicts, instructors are encouraged to consider the timing of holy days when scheduling class events. For further information, including a list of days of religious observances, please contact the Equity and Human Rights Office or visit their website: <web.uvic.ca/eqhr>

Discrimination and Harassment Policy (GV0205)

http://web.uvic.ca/calendar/general/policies.html

Standards for Professional Behaviour

"It is the responsibility of all members of the Faculty of Engineering, students, staff and faculty, to adhere to and promote standards of professional behaviour that support an effective learning environment that prepares graduates for careers as professionals…."

You are advised to read the Faculty of Engineering Document Standards for Professional Behaviour which contains important information regarding conduct in courses, labs, and in the general use of facilities.
https://www.uvic.ca/engineering/assets/docs/professional-behaviour.pdf

Policy on Academic Integrity

Cheating, plagiarism and other forms of academic fraud are taken very seriously by both the University and the Department. You should consult the Undergraduate Calendar http://web.uvic.ca/calendar/undergrad/info/regulations/academic-integrity.html for the UVic policy on academic integrity.

Equality

This course aims to provide equal opportunities and access for all students to enjoy the benefits and privileges of the class and its curriculum and to meet the syllabus requirements. Reasonable and appropriate accommodation will be made available to students with documented disabilities (physical, mental, learning) in order to give them the opportunity to successfully meet the essential requirements of the course. The accommodation will not alter academic standards or learning outcomes, although the student may be allowed to demonstrate knowledge and skills in a different way. It is not necessary for you to reveal your disability and/or confidential medical information to the course instructor. If you believe that you may require accommodation, the course instructor can provide you with information about confidential resources on campus that can assist you in arranging for appropriate accommodation. Alternatively, you may want to contact the Resource Centre for Students with a Disability located in the Campus Services Building.

The University of Victoria is committed to promoting, providing, and protecting a positive, and supportive and safe learning and working environment for all its members."

COURSE SCHEDULE

Week 1 (May 7) - Introduction to course & project		
Exercise 1: Setup computer	Review syllabus Review each system toymodel Ensure students can run the jupyter notebooks Ensure the modelling environment set up Create GitLab username Access and clone Git repo Send sector/toymodel preference to TA Finalize groups	Exercise #1 Assessment
Week 2 (May 14) – Review energy systems & modelling background resources		
Exercise 2: Energy Systems Exercise 3: Introduction to modelling	Begin Proposal Presentation development Review energy systems material (Exercise 2) Review modelling material (Exercise 3) Work on Exercise Assessments #2 and #3	Exercise #2 Assessment Exercise #3 Assessment
Week 3 (May 21)– Model exploration		
Exercise 4: Explore project ideas Read sector-specific paper	Run the sectoral toymodel Explore interesting directions (Exercise 4) Develop project ideas, direction, and work plan Work on Exercise Assessment #4	Exercise #4 Assessment
Week 4 (May 28)– Deliver Proposal Presentation		
	Each group will deliver their Proposal Presentation Students should provide feedback to other groups Work towards Progress Evaluation #1	Project Proposal Presentation
Week 5 (June 4)– Model development focused on data & optimization		
Exercise 5: Introduction to Python and pandas Exercise 6: Introducing optimization with pyomo	Run the sectoral toymodel Analyze data input (Exercise 5) Review model framework (Exercise 6) Run model over several iterations Validate/ sanity check results Perform a preliminary results analysis Explore model sensitivities to input data or framework Work towards Progress Evaluation #1	Exercise #5 Assessment Exercise #6 Assessment
Week 6 (June 11)– Model development & Progress Evaluation #1		
	TA/Instructor circulate to evaluate the groups' progress Work towards Progress Evaluation #2	Progress Evaluation #1
Week 7 (June 18)– Model development focused on visualizations		
Exercise 7: Visualizations	Assemble the first set of results & analysis Develop preliminary visualizations (Exercise 7) Articulate the results of interest Work towards Progress Evaluation #2	Exercise #7 Assessment
Week 8 (June 25) – Model development & Progress Evaluation #2		
	TA/Instructor circulate to evaluate the groups' progress Work towards Progress Evaluation #3	Progress Evaluation #2
Week 9 (July 2)–READING BREAK		
Week 10 (July 9) – Model development focused on scenario analysis		

Exercise 8: Developing a scenario matrix	Develop scenario matrix (Exercise 8) Run model for scenario matrix Work towards Progress Evaluation #3	Exercise #8 Assessment
Week 11 (July 16)– Model development & Progress Evaluation #3		
	TA/Instructor circulate to evaluate the groups' progress Work towards Final Presentation	Progress Evaluation #3
Week 11 (July 23) - Self-led		
Week 12 (July 30) – Final Presentations		
	Each group will deliver their Final Presentation	Peer feedback