

# CHE 4A03/6A03 Syllabus for 2020

Energy Systems Engineering

## Description

Cradle-to-grave overview of major gas, coal, nuclear, biomass, petroleum, solar, and wind energy resources, networks, and systems. Gasification, fuel cells, polygeneration, synthetic fuels, alternative fuels.



## Learning Objectives (brief)

The purpose of the course is to provide students with a background in energy systems engineering. This course provides the necessary background information in how the largest and most important components of major energy systems work individually and how they fit into the larger system. In addition, the student will get experience in the basics of engineering systems design in an experiential learning environment. As a chemical engineering course, there is a larger focus on systems and components which use chemical pathways, but since the field is interdisciplinary by nature, a broad range of topics are covered. Students who complete this course should be able to:

- **Construct cradle-to-product supply chains** of major energy products, including the major components in the associated energy system.
- **Calculate product and energy flows** across a supply chain and **determine** some associated environmental impacts.
- **Design energy systems** for various applications, from scales ranging from building to nation, using systems methodologies.
- **Assess the quality of energy systems** using a variety of metrics.
- **Make informed recommendations** about energy systems design decisions within the context of the triple bottom line of sustainability.
- **Demonstrate relevant knowledge of major energy system components**, including resource production, energy conversion, energy transportation, and energy storage.
- **Employ modern computing software** which can aid in the modeling and design of energy systems.

## Course Details

- Instructor:** Prof. Thomas A. Adams II  
tadams@mcmaster.ca
- Website:** On Avenue to Learn  
MS Teams Channel (Lectures)
- Teaching Assistants:**  
To be determined
- Lectures:** We, Th 10:30-11:20 MSTeams
- Tutorials:** T1: Mo 8:30-10:20 MSTeams  
T2: Th 12:30-2:20 MSTeams
- Office Hours:** To Be Determined MSTeams  
See Ave2Learn Calendar for  
TA Office Hours
- Prerequisites:** CHE 3G04
- Materials:** Tutorials, assignments, slides, readings, announcements, and solutions will be posted on the course website. Course pack available. Grades will be posted but are not official.
- Required Texts:** Many resources, textbooks, data sets, journal articles, etc. See pages 4-6. All required readings will be made freely available to students (legally).
- Course Pack:** Optional. Printed pack available via university bookstore (delivery!), and PDFs available on course website for free.

# Course Policies

## Grading Policies

- Late submissions or missed oral presentations will not be accepted w/o an 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".
- Valid MSAF forms for quizzes, tutorials, and project milestones will result in **weight transferring** to the final.
- Digital submissions for written materials are through Avenue to Learn unless otherwise instructed. If technical difficulties occur, email a TA with the material before the deadline.
- Due to the nature of the all-online course, all exams will be open book and open notes.

## Rules for Curving

Graded material will not be curved. The final course grade will be curved in your favor as follows:  $x$  points will be added to your score, where  $x = 90$  minus the **second highest score**. However  $x$  will never be larger than 10 or smaller than zero. Fractions of points will be rounded up. Final course percentage grades will be converted to **letter grades according to normal University policy**. I reserve the right to change the curve, but only in your favour and only in extreme circumstances.

**Example:** Priya got a 65.1 in the course. The top three students earned a 89, 86, and 81. Priya's curved course grade is  $65.1 + (90 - 86) = 69.1\%$ , rounds up to a 70%. This is reported as a B- to the registrar.

## Grading Breakdown

Wt.%	Component	Comments
12%	Tutorials	9 Tutorials – <b>Points for completing</b>
20%	Midterm	"Take home" style with oral presentations on <b>Oct 22</b> .
30%	Final Exam	"Take home" style with oral presentation. TBD.
8%	Quizzes	Very short quizzes due before lecture. <b>Points for trying.</b>
30%	Design Project	Broken into individual milestones. See next page.

## Academic Honesty

- All tutorials, quizzes and exams are to be done individually, with no collaboration with anyone. Midterm "re-takes" will be done in assigned groups.
- Plagiarism, improper collaboration, copying unauthorized tests or aids, and other academic dishonesty will not be tolerated. **Your first offence will be reported** to the Office of Academic Integrity.
- The default penalty for academic dishonesty is a zero on the entire exam / quiz / project, even if the dishonesty occurred on just one portion or question of that exam / quiz / project. However, if Academic Integrity chooses to hold a hearing, they determine the penalty which replaces the default penalty.

**Note:** 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. 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-procedures-guidelines/>

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.

## Design Projects

Term projects will be completed in groups of up to four. **The project will be comprehensive and include everything learned in the course.** You will complete the project in stages over the course of the term by meeting the required project milestones (which will be graded).

**You will be permitted to choose your own groups.** If you are not part of a group I will assign you to a group. I may have to assign you to a group that has already formed. I have executive power to reassign and reform any group as I please, but I will only do this if the system is abused or if extreme circumstances warrant.

**The term projects will be delivered in written form, including with supporting materials such as simulation code, spreadsheets, calculations, and written deliverables.** Points will be awarded for both technical accuracy as well as quality of the communication. Portions of the project will be delivered as “milestones” during the term.

The project will be related to synthesizing and analyzing an energy system which can be used meet certain consumer demands. Groups will present decisions according to key metrics and within the context of the triple-bottom-line of sustainability.

## Variation for 6A03 Students

Students taking the grad-school version of the course (6A03) must complete the project on their own (no groups). The university requires that students in 600 level courses have a greater challenge than 400 level students in some way.

## Design Project Deadlines

**Milestone 1:** 15% - Due Sep 22

**Milestone 2:** 15% - Due Oct 9

**Milestone 3:** 15% - Due Nov 6

**Milestone 4:** 15% - Due Nov 24

**Final Report:** 40% - Due Dec 9

## Midterm

The midterm take place over a 1-2 week period ending Thursday Oct 22. You will be given the exam questions 1-2 weeks before Oct 22 and have time to work on them. You will submit written answers via Avenue 2 Learn by 11:59pm on Oct 21. On October 22, you will be assigned a timeslot in which you will present and defend those written answers to us orally. The grades will be assigned based on the oral defense of the written answers. Written answers alone will not be marked.

Basically, we can tell if you know your own answers or not by asking you questions about them.

A valid MSAF causing the written submission to be missed will cause the weight from the midterm to be transferred into the final.

A valid MSAF causing the oral portion to be missed but not the written portion (i.e.. an on-time written submission was received) will cause a reschedule of the oral defense.

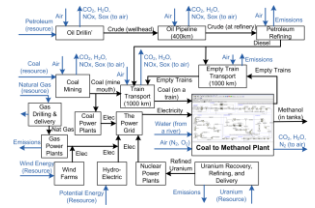
## Final Exam

The final exam will be in a similar format, with the oral component taking place on the day assigned by the registrar. Due to scheduling limitations, a day before or after the scheduled day may have to be used for some oral defense slots.

# Course Calendar (subject to change!)

## 1. Key Tools in Energy Systems

Synthesizing supply chains. Life cycle inventories. Key metrics in assessment (efficiencies, environmental impacts, etc)

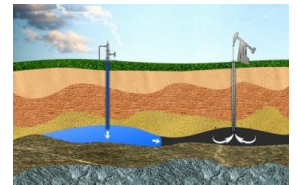


Day	Topic	In Class Quiz?	Reading
Sep 9	Lecture 1.1: Life Cycle Inventories and Supply Chains		
Sep 10, 16	Lecture 1.2: Key Metrics in Energy Systems Engineering	Quiz	B1§1.6, B2§3.5.3
Sep 10/14	Tutorial 1: Computing Inventories and Impacts		T1 pg 1-3

See page 6 for what the reading abbreviations mean...

## 2. Energy Resource Production

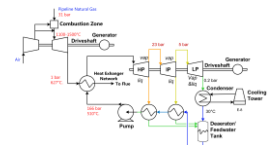
Coal mining, gas & oil drilling, recovery, and production, biomass harvesting. Transportation of crude and refine basic energy products.



Day	Topic	In Class Quiz?	Reading
Sep 17	Lecture 2.1: Coal Production	Quiz	B3§5.3
Sep 17/21	Tutorial 2: Basic Dynamic Modelling with Aspen Custom Modeller.		T2 pg 1-4
Sep 23, 24	Lecture 2.2: Natural Gas Production	Quiz	B3§2.3-2.5
Sep 24/28	Tutorial 3: Designing and Computing Impacts For Energy Systems		
Sep 30	Lecture 2.3: Biomass Production, Harvesting, and Recovery		B1§14.1-14.3
Oct 1	Lecture 2.4: Petroleum, Bitumen, and Synthetic Crude Production		B3§3.1-3.2, 4.1.1, 4.4

## 3. Municipal Energy Services (Current)

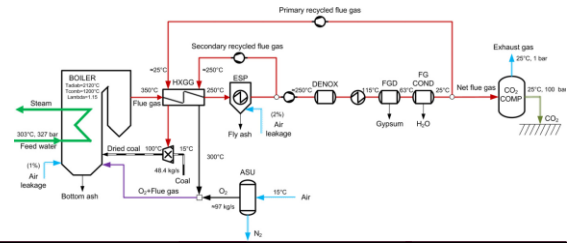
Stationary power generation from fossil fuels (legacy and state of the art). Nuclear systems. Renewable power. Energy storage. Carbon dioxide capture. Oil and gas heating systems.



Day	Topic	In Class Quiz?	Reading
Oct 1/5	Tutorial 4: Peaking power plants		
Oct 7	Lecture 3.1: Pulverized Coal Power Plants	Quiz	B6§1.1.4
Oct 8	Lecture 3.2: Natural Gas Power Plants and Gas Heating		B6§2.2.19
Oct 8/19	Tutorial 5: Designing Power Grid Systems (Basic)		
Oct 21	Lecture 3.3: Nuclear Power Plants	Quiz	B1§8.3.1-8.4
Oct 22	<b>No Lecture – Midterm Oral Defense Day</b>		
Oct 28	Lecture 3.4: Solar Power Plants		B1§10.4,11.5.1-11.5.4
Oct 29	Lecture 3.5: Wind and Hydroelectric Power Plants	Quiz	B1§13
O29/Nov2	Tutorial 6: Optimization Approaches to Designing Power Grid Systems		B4§21.4 to Fig 21.5
Nov 4	Lecture 3.6: Co-Generation and Integrated Community Energy Systems		B8§19
Nov 5/9	Tutorial 7: Blackout! The power grid management video game.		

## 4. Future Bulk Electric Power Systems

Future power systems. Integrated gasification combined cycles, oxyfuels, chemical looping combustion, fuel cells.



Day	Topic	In Class Quiz?	Reading
Nov 5	Lecture 4.1: IGCC (Integrated Gasification Combined Cycle)		J1§1.2
Nov 11, 12	Lecture 4.2: Carbon Dioxide Capture and Sequestration		B1§7.4-7.5&7.7
Nov 12/16	Tutorial 8: Sizing Renewable Energy Systems		
Nov 18	Lecture 4.3: Oxyfuel Combustion	Quiz	J1§1.3
Nov 19	Lecture 4.4: Chemical Looping Combustion		J1§1.3
Nov 19/23	No tutorials, only mentorship meetings.		
Nov 25	Lecture 4.5: Fuel Cells	Quiz	B7§9

## 5. Transportation Fuels

Petroleum refining. Regulations and emissions. Biofuels from biological and thermochemical routes. Synthetic fuels. Alternative Fuels.



Day	Topic	In Class Quiz?	Reading
Nov 26	Lecture 5.1: Petroleum Refining	Quiz	B3§3.3, 3.5
Nov 26/30	Tutorial 9: Transportation Fuel Distribution		
Dec 2	Lecture 5.2: Biofuels		B3§8.4, B7§1.14
Dec 3	Lecture 5.3: Synthetic Fuels	Quiz	B3§5.6
Dec 3/7	No tutorials, only mentorship meetings.		
Dec 9	Lecture 5.4: Alternative Fuels – Short Version		B2§1.11.2
Dec 9	Lecture 5.5: Polygeneration Systems – Short Version	Quiz	J2

# Reading List

## Couse Materials

There is no one textbook that covers everything that we need for the course. Part of the problem is that the world of energy is always changing, and so textbooks can quickly become out of date. Therefore, we will use a wide variety of sources, many which update each year.

The lecture and tutorials themselves form the majority of your course material (and are available as a course pack from the university bookstore). Citations for sources are provided on each slide or page as appropriate.

## Reading Assignments

Check the syllabus schedule for required readings that should be completed prior to attending lectures or tutorial. I try to keep it really short and sweet. Some days, there will be a quiz over the assigned material.

The syllabus uses the following notation:

**Tutorials:** Tx pg y-z: Read pages y-z of Tutorial x before coming into tutorial. This will save you valuable time.

**Books:** Bx&s: Read section s of Book x (see list at right!)

**Journals:** Jx: Read journal article x from the list.

## Free Book Sources

I try to use free sources for your books since we have to pick and choose from so many resources. Many books are either available from the library website or through Access Engineering. For Access Engineering, go to [library.mcmaster.ca](http://library.mcmaster.ca) from a campus IP address (or I think you can also log into the website with your usual MacID). Then search for Access Engineering in the library catalogue, and enter it that way. From there, search for the book by title. You can bookmark it at that point to save time in the future. Remember, all members of the Canadian Society for Chemical Engineering also get free access to Access Engineering as long as they are members! A great resource after you graduate.

### Textbooks

*Free to McMaster Students from Access Engineering  
Published by McGraw-Hill:*

B1. Vanek FM, Albright LD, and Anganent LT. **Energy Systems Engineering: Evaluation & Implementation**, 3rd Ed. (2016)

B2. Heywood JB. **Internal Combustion Engine Fundamentals**, 2<sup>nd</sup> Edition. (2018)

B3. Speight JG. **Synthetic Fuels Handbook: Properties, Process, and Performance**. (2008)

B4. Santoso S, Beaty HW. **Standard Handbook for Electrical Engineers**, Seventeenth Ed. (2018)

B5. Jayamaha L. **Energy-Efficient Industrial Systems: Evaluation and Implementation**. (2016)

B6. Woodruff EB, Lammers HB, Lammers TF. **Steam Plant Operation**, 10<sup>th</sup> Edition. (2017).

B7. Nag A. **Biofuels Refining and Performance**. (2008)

B8. Meckler M, Hyman L. **Sustainable On-Site CHP Systems: Design, Construction, & Operations**. (2010)

*Other Publishers, free e-Book from McMaster Library:*

B9. Jimenez-Gonzales C and Constable DJC. **Green Chemistry and Engineering: A practical design approach**. (2011) Wiley.

B10. Ghosh TK and Prelas MA. **Energy Resources and Systems, Volume 1: Fundamentals and Non-Renewable Resources**. (2009) Springer.

B11. Spliethoff H. **Power Generation from Solid Fuels**. (2010) Springer.

B12. Wood, Janet. **Nuclear Power**. (2007), Stevenage IET.

### Journal Articles

J1. Adams TA II, Hoseinzade L, Madabhusi PM, Okeke IJ. **Comparison of CO<sub>2</sub> Capture Approaches for Fossil-Based Power Generation: Review and Meta-Study**. *Processes* 5:44 (2017). Download here: <http://psecommunity.org/LAPSE:2018.0134>

J2. Adams TA II, Ghouse J. **Polygeneration of Fuels and Chemicals**. *Current Opinion Chem Eng* 10:87-93 (2015). Search for it on journal website while on a campus IP. Or, direct link is: <https://www.sciencedirect.com/science/article/pii/S2211339815000623>

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# Additional Course Policies

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## Conduct Expectations

As a McMaster graduate 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 Microsoft Teams, 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 of Students with Disabilities

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

## Religious, Indigenous, or Spiritual Observances (RISO)

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 accomod-

ation 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.

## 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.

## 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.

## On-Line Elements

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.