Energy and the Environment Syllabus

Department of Physics and Atmospheric Science

PHYC/ENVS 2310 Winter 2026

Dalhousie University operates in the unceded territories of the Mi'kmaw, Wolastoqey, and Peskotomuhkati Peoples. These sovereign nations hold inherent rights as the original peoples of these lands, and we each carry collective obligations under the Peace and Friendship Treaties. Section 35 of the Constitution Act, 1982, recognizes and affirms Aboriginal and Treaty rights in Canada.

We recognize that African Nova Scotians are a distinct people whose histories, legacies, and contributions have enriched the part of Mi'kma'ki known as Nova Scotia for over 400 years.

Course Instructor(s)

Name	Email	Office Hours
Michael Metzger	michael.metzger@dal.ca	Monday, Wednesday, Friday 14.30-15.00, Dunn building, Room 329
Andrew Hess	andrew.hess@dal.ca	-

Course Description

This course covers the physical principles and opportunities of renewable energy resource utilization and the fundamentals of energy conversion. It provides a quantitative introduction to electricity generation from fossil, nuclear and renewable resources, e.g., solar, wind and hydroelectricity. The impact of various energy technologies on the global climate and environment will be discussed

Course Prerequisites

PHYC 1190.03/1290.03 (or PHYC 1310/1320), CHEM 1011.03/1012.03, and MATH 1000.03 (or MATH 1215.03), or permission by the instructor.

Course Exclusions

Students who have previously taken PHYC 3330 cannot take PHYC 2310.

Student Resources

Office hours will be held after every lecture, i.e., Monday, Wednesday, Friday 14.30 – 15.00, in the Dunn building in room 329. There will be a help page on Brightspace for questions and answers regarding course materials and assignments. Announcements related to the course will be communicated through the course website on Brightspace. Additionally, please check your Dalhousie email for course related communications.

Course Structure

Course Delivery

The course will be delivered in person and not recorded. We will use slide decks for each chapter (see below) to discuss the relevant contents. PDFs of all slides will be made available on the Brightspace page prior to lectures. During the course, examples may be given by the instructor using an iPad. It is expected that the students will write down these examples in their notes for later reference.

Lectures

Monday, Wednesday, Friday 13.35-14.25, Studley LSC-COMMON AREA C242

Tutorials

Individually scheduled Q&A sessions will be offered before the assignment due dates.

Course Materials

- Required textbook: "Sustainable Energy" by Richard A. Dunlap, 2nd US Edition, 2019 Cengage Learning, Inc. ISBN: 978-1-337-55166-3. The Dalhousie bookstore has copies of this textbook. Students should purchase either new or used copies (2nd Edition only) of the textbook.
- Brightspace page: **ENVS2310 PHYC2310 - Energy and the Environment - Sec: 01 - 2025/2026 Winter**.
- Slides: We will use slide decks for each chapter (see below) to discuss the relevant contents. PDFs of all slides shown in the course will be made available on the Brightspace page.
- Examples: During the course, examples of quantitative analyses will be given by the instructor to illustrate and reinforce the learning of scientific concepts. It is expected that the students write down these examples in their notebooks for later reference.

Assessment

The problem sets in the homework assignments will be very close to the examples provided during the lectures. Assignment problems will be posted on the Brightspace page. Students will need access to a computer to upload problem solutions to the Brightspace page.

Assignments and Exams

Assignment #A	*10% of final grade*	*Start: January 16, 2026 / Due: January 30, 2026*
Assignment #B	*10% of final grade*	*Start: January 30, 2026 / Due: February 11, 2026*
Assignment #C	*10% of final grade*	*Start: February 11, 2026 / Due: February 25, 2026*
Midterm exam	*10% of final grade*	*Date: February 27, 2026*
Assignment #D	*10% of final grade*	*Start: February 25, 2026 / Due: March 11, 2026*
Assignment #E	*10% of final grade*	*Start: March 11, 2026 / Due: March 25, 2026*
Assignment #F	*10% of final grade*	*Start: March 25, 2026 / Due: April 8, 2026*
Final exam	*30% of final grade*	*Scheduled exam period: April 11-27, 2026*

Conversion of numerical grades to final letter grades follows the Dalhousie Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D (50-54)
A (85-89)	B (73-76)	C (60-64)	F (0-49)
A- (80-84)	B- (70-72)	C- (55-59)	

Course Policies on Missed or Late Academic Requirements

- Students are expected to use the Student Declaration of Absence (SDA) form for late assignments. The form may be used 2 times in this course. With SDA assignments can be handed in 1 week late without reduced points.
- If solutions to assignments are handed in up to 1 week late and no SDA was submitted, they will count half (5% of final grade).
- If solutions to assignments are handed in more than 1 week after the due date and no SDA was submitted, they will count zero.

Course Policies related to Academic Integrity

It is encouraged that students discuss assignment problems as a group. However, it is an academic offense to copy the solution of someone else or to use generative AI and large language models (e.g., ChatGPT). Allegations will be submitted to an Academic Integrity Officer of the Faculty of Science for evaluation and possible sanctions. The minimum sanction is zero point on the assignment.

Learning Objectives

Students should develop a general understanding of the global energy demand, conventional methods of electricity production, our rate of fossil fuel resource utilization, renewable energy sources and the need for energy conversion and storage. They should learn the fundamental physical laws governing energy conversion and storage as well as be able to perform quantitative analyses of energy resources.

Key Concepts

- Physical principles and limitations of renewable energy utilization
- Hubbert model of resource utilization
- Physical science basis of climate change
- Fundamentals of energy conversion
- Carnot efficiency, heat engines, heat pumps
- Quantitative analysis of electricity generation from fossil, nuclear and renewable resources, e.g., solar, wind and hydroelectricity
- Impact of various energy technologies on the global climate and environment

Time Available

- Carbon footprint analysis

Learning Objectives

- General understanding of the global energy demand
- Understand conventional methods of electricity production
- Calculate rate of fossil fuel resource utilization
- Availability and potential of renewable energy sources
- Fundamental physical laws governing energy conversion and storage
- Quantitative analyzes of energy resources

Course Content

During the term, we will attempt to cover the most important contents of the “Sustainable Energy” textbook as well as supplementary material grouped in the below chapters. If appropriate and available, industry experts will be invited to give guest lectures. The class material requires simple calculus and diligent reading.

Table of Contents

4.3. Solar Thermal Electricity Generation

4.3.1. Parabolic Dishes

4.3.2. Central Receivers

4.4. Photovoltaics

4.4.1. Basic Semiconductor Physics

a) Energy Levels

b) Electron-hole Pairs

4.4.2. Photovoltaic Devices

4.4.3. Cost of Photovoltaics

4.4.4. Global Use of Photovoltaics

4.4.5. Combined Solar and Battery Application

Chapter 5: Wind Energy

5.1. Wind Turbine Design

a) Pressure Gradients

b) Wind Turbine Types

c) Main Turbine Components

5.2. Obtaining Energy from the Wind

a) Moving Parcel of Air

b) Betz Limit for Wind Turbines

c) Cut-in Speed

d) Wind Turbine Examples

5.3. Applications of Wind Power

a) Optimal Turbine Placement

b) Areal Power

c) Practical Limitations of Empowering

d) Onshore vs. Offshore Generation

e) Wind Energy Challenges

Chapter 6: Energy from Water

6.1. Hydroelectricity

6.1.1. Turbine Design

a) Generate Energy from Water

b) Turbine Types

6.1.2. High and Low Head Systems

a) Dams

b) Run-of-the-river Systems

6.1.3. Utilization of Hydroelectricity

a) Installed Capacity

b) Impact on Environment

6.1.4. Pumped Hydro

a) Peak and Base Load

b) Operating Principle

6.1.5. Other Gravity Energy Storage

6.2. Energy from the Ocean

6.2.1. Wave Energy

a) Energy from Waves

b) Wave Power Devices

c) Wave Energy Resources

6.2.2. Tidal Energy

a) Energy from the Tides

b) Barrage Systems

c) Underwater Turbines

6.2.3. Exploratory Ocean Energy

Chapter 7: Geothermal Energy

7.1. Origins of Geothermal Energy

7.1.1. Internal Structure of the Earth

7.1.2. Geothermal Gradients

7.2. Uses of Geothermal Energy

7.2.1. Heat Pumps

a) Air Source Heat Pumps

b) Ground Source Heat Pumps

c) Air Conditioners

7.2.2. Geothermal Electricity

a) Dry Steam Plants

b) Flash Steam Plants

c) Binary Power Plants

7.3. Utilization of Geothermal Electricity

7.3.1. Installed Capacity and Distribution

7.3.2. Environmental Consequences

7.4. Geo(-thermal) Energy Storage

7.4.1. Compressed Air Energy Storage

7.4.2. Thermal Energy Storage

Chapter 8: Renewables Integration

8.1. Possible Energy Futures

8.1.1. Future Electricity Production

8.1.2. “Renewable Electricity Futures” Study

8.1.3. “North American Renewable Integration” Study

8.2. IPCC Report on Mitigation of Climate Change

8.2.1. The Cost of Renewables

8.2.2. Greenhouse Gas Emissions Reduction

8.3. Tesla Master Plan Part 3

8.3.1. The Plan to Eliminate Fossil Fuels

8.3.2. Modeling The Fully Sustainable Energy Economy

8.3.3. Model Results

8.3.4. Investment, Land Area, and Materials Required

Tentative course schedule lecture-by-lecture

Week	Date	Lesson Topic(s)	Assignment
1	January 7	Lecture 1: 1.1. The IPCC Report on Climate Change	Reading
1	January 9	Lecture 2: 1.2. Energy Fundamentals	Reading
2	January 12	Lecture 3: 1.3. World Energy Usage	Reading
2	January 14	Lecture 4: 1.4. Pollution	Reading
2	January 16	Lecture 5: 1.5. Global Warming	Start: Assignment #A
3	January 19	Lecture 6: 1.6. Fighting Climate Change	Reading
3	January 21	Lecture 7: 2.1. Energy From Fossil Fuels	Reading
3	January 23	Lecture 8: 2.2. The Laws of Thermodynamics	Reading
4	January 26	Lecture 9: 2.3. Converting Heat to Electricity	Reading
4	January 28	Lecture 10: 2.4. Traditional Energy Sources	Reading
4	January 30	Lecture 11: 2.5. Resource Availability	Due: Assignment #A Start: Assignment #B
5	February 2	Lecture 12: 3.1. Basic Nuclear Physics - 1	Reading
5	February 4	Lecture 13: 3.1. Basic Nuclear Physics - 2	Reading
5	February 6	Munro Day	-
6	February 9	Lecture 14: 3.2. Nuclear Fission - 1	Reading
6	February 11	Lecture 15: 3.2. Nuclear Fission - 2	Due: Assignment #B Start: Assignment #C
6	February 13	Lecture 16: 3.2. Nuclear Fission - 3	Reading
7	February 16	Nova Scotia Heritage Day	Study for Midterm
7	February 18	Winter Study Break	Study for Midterm
7	February 20	Winter Study Break	Study for Midterm
8	February 23	Lecture 17: 3.3. Nuclear Safety	Reading

8	February 25	Lecture 18: 3.4. Nuclear Fusion	Due: Assignment #C Start: Assignment #D
8	February 27	Midterm Exam	-
9	March 2	Lecture 19: 4.1. Solar Fundamentals	Reading
9	March 4	Lecture 20: 4.2. and 4.3. Solar Thermal Energy	Reading
9	March 6	Lecture 21: 4.4. Semiconductor Physics	Reading
10	March 9	Lecture 22: 4.4. Photovoltaics	Reading
10	March 11	Lecture 23: 4.4. Application of Photovoltaics	Due: Assignment #D Start: Assignment #E
10	March 13	Lecture 24: 5.1. Wind Turbine Design	Reading
11	March 16	Lecture 25: 5.2. Obtaining Energy from the Wind	Reading
11	March 18	Lecture 26: 5.3. Applications of Wind Power	Reading
11	March 20	Lecture 27: Guest Lecture by Natural Forces	Reading
12	March 23	Lecture 28: 6.1. Hydroelectricity - 1	Reading
12	March 25	Lecture 29: 6.1. Hydroelectricity - 2	Due: Assignment #E Start: Assignment #F
12	March 27	Lecture 30: 6.2. Energy from the Ocean	Reading
13	March 30	Lecture 31: 7. Geothermal Energy - 1	Reading
13	April 1	Lecture 32: 7. Geothermal Energy - 2	Reading
13	April 3	Good Friday	-
14	April 6	Lecture 33: 9. Renewables Integration - 1	Reading
14	April 8	Lecture 34: 9. Renewables Integration - 2	Due: Assignment #F
-	TBD	Final Exam	-

University Policies and Statements

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit or e-mail the Indigenous Student Centre at 1321 Edward St or elders@dal.ca. Additional information regarding Mi'kmaq and Indigenous Relations (including the Elders in Residence program, Land Acknowledgements, Understanding Our Roots, and much more) can be found at: https://www.dal.ca/about/mission-vision-values/mikmaq-indigenous-relations.html

Internationalization

At Dalhousie, 'thinking and acting globally' enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders." Additional internationalization information can be found at: https://www.dal.ca/about/mission-vision-values/global-relations.html

Academic Integrity

At Dalhousie University, we are guided in all our work by the values of academic integrity: honesty, trust, fairness, responsibility, and respect. As a student, you are required to demonstrate these values in all the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. Additional academic integrity information can be found at: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation. If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion, please contact the Student Accessibility Centre (https://www.dal.ca/campus_life/academic-support/accessibility.html) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (https://www.dal.ca/campus_life/ssc.html).

Conduct in the Classroom – Culture of Respect

Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2). Additional diversity and inclusion information can be found at: https://www.dal.ca/about/mission-vision-values/equity-diversity-inclusion-and-accessibility/about-office-equity-inclusion.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner - perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. The full Code of Student Conduct can be found at: https://www.dal.ca/content/dam/www/about/leadership-and-governance/governing-bodies/code-student-conduct.pdf

Fair Dealing Policy

The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie. Additional information regarding the Fair Dealing Policy can be found at: https://www.dal.ca/content/dam/www/about/leadership-and-governance/university-policies/fair-dealing-policy.pdf

Student Use of Course Materials

Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.

Faculty of Science

Student Resources and Support

University Policies and Programs

Important Dates in the Academic Year (including add/drop dates): http://www.dal.ca/academics/important_dates.html

Classroom Recording Protocol: https://www.dal.ca/content/dam/www/about/leadership-and-governance/university-policies/class-recording-protocol.pdf

Dalhousie Grading Practices Policies: https://www.dal.ca/content/dam/www/about/leadership-and-governance/university-policies/grading-practices-policy.pdf

Grade Appeal Process: https://www.dal.ca/campus_life/academic-support/grades-and-student-records/appealing-a-grade.html

Sexualized Violence Policy: https://www.dal.ca/content/dam/www/about/leadership-and-governance/university-policies/sexualized-violence-policy.pdf

Scent-Free Program: https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html

Learning and Support Resources

General Academic Support – Advising (Halifax): https://www.dal.ca/campus_life/academic-support/advising.html

General Academic Support – Advising (Truro): https://www.dal.ca/campus_life/ssc.html

Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness.html

On Track (helps you transition into university, and supports you through your first year at Dalhousie and beyond): https://www.dal.ca/campus_life/academic-support/On-track.html

Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html

Mi'kmaq and Indigenous Relations: https://www.dal.ca/about/mission-vision-values/mikmaq-indigenous-relations.html

Elders-in-Residence (The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit the office in the Indigenous Student

Centre or contact the program at elders@dal.ca or 902-494-6803: https://www.dal.ca/about/mission-vision-values/mikmaq-indigenous-relations/elders-in-residence-and-traditional-knowledge-keepers.html

Black Student Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html

International Centre: https://www.dal.ca/campus_life/international-centre.html

LGBTQ2SIA+ Collaborative: https://www.dal.ca/about/mission-vision-values/equity-diversity-inclusion-and-accessibility/about-office-equity-inclusion/community-specific-groups/lgbtq2sia-collaborative.html

Dalhousie Libraries: http://libraries.dal.ca/

Copyright Office: https://libraries.dal.ca/services/copyright-office.html

Dalhousie Student Advocacy Services: https://www.dsu.ca/dsas?rq=student%20advocacy

Dalhousie Ombudsperson: https://www.dal.ca/campus_life/safety-respect/ombudsperson.html

Human Rights and Equity Services: https://www.dal.ca/about/mission-vision-values/equity-diversity-inclusion-and-accessibility/about-office-equity-inclusion/human-rights-and-equity-services.html

Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html

Study Skills/Tutoring: http://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

Faculty of Science Advising Support: https://www.dal.ca/faculty/science/current-students/undergrad-students/degree-planning.html

Safety

Biosafety: http://www.dal.ca/dept/safety/programs-services/biosafety.html

Chemical Safety: https://www.dal.ca/dept/safety/programs-services/chemical-safety.html

Radiation Safety: http://www.dal.ca/dept/safety/programs-services/radiation-safety.html

Laser Safety: https://www.dal.ca/dept/safety/programs-services/radiation-safety/laser-safety.html