MARYLAND APPLIED GRADUATE ENGINEERING

Environmental Energy Security (ENPM626)
Sections DE01

Professor: Patrick Caton, Ph.D., P.E.
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Office Hours: Mondays 2000-2300; Wednesdays 1900-2200; and by arrangement.

Term: Summer 2026
Credits: 03
Term Dates: From June 1 – August 21

Course Times: Online
Classroom: N/A

Canvas/ELMS: https://umd.instructure.com/courses/1408032

Course Description

One of the defining questions of the 21st century is the following: How can we, as a nation and as a world community, meet an ever-growing hunger for energy while simultaneously avoiding catastrophic damage to our environment through pollution or climate change? This question continues to drive policy debates around the world. The unrestrained use of the cheapest and/or most convenient energy has resulted in a global collective action problem with many possible solutions, but few easy answers.

The overall objective of this course is to develop a toolkit to evaluate the energy security – and in particular, the environmental energy security – of available energy resources and conversion technologies, including those in current use, and those that might be used in the foreseeable future. Energy security is evaluated using a simple three-dimensional model based in the academic literature. This is an engineering class, and while we must occasionally delve into related economics and policy issues, we will focus on the core technical competencies in energy conversion needed to navigate the current world of energy.

The class is focused on four themes or questions. First, what are the available energy resources on Earth, both renewable and not? Second, what is the demand for energy on Earth and from particular countries? The third theme is that not all these energy sources are equal, particularly from a perspective of energy security, but also for particular sectors (cement, steel, aviation). The final course theme is how these resources and technologies could be creatively applied to meet human demands while addressing environmental energy security. Throughout the course, we will consider current data from reputable international sources – data that are destined to change with time and technology developments. There is little value in memorizing exact figures, but there is value in generating an intuition for typical values. Furthermore, as we consider data, the goal of this class is to help students ask the right critical questions of the data, such as “Is this estimate high or low?” “What are the critical factors the source

should have considered, and did they?" "Why might this value be wrong?" "How does my thinking change if the actual value was higher or lower?" In this way, we aim to develop evaluative thinking about all things energy.

Prerequisites

Undergraduate courses in thermodynamics and heat transfer.

Learning Outcomes

After successfully completing this course, you will be able to:

- Evaluate technical reports about energy systems with an intuition for energy accounting on a variety of scales (local, national, global) using a variety of unit systems.
- Classify the fundamental resources on Earth and calculate the exergy of each (exergy analysis), identifying as-yet unrealized potential in the Earth system.
- Predict how current climate science will likely affect future energy systems.
- Apply a simple model of energy security to determine how future technologies may be more or less secure.
- Evaluate candidate technologies by asking the right questions based on the best current energy data.

Course Materials

- Students will be required to use computer software to complete assignments including Excel and MATLAB.

- There is no required textbook for the course. Weekly readings will be from published academic literature. Lecture slides have been developed based on published and peer-reviewed journal articles, technical energy articles, and on several textbooks, which are listed below for reference as optional resources:

    - Bui, M. & Mac Dowell, M. Eds. Carbon Capture and Storage. Royal Society of Chemistry, 2020.

    - Bui, M. & Mac Dowell, M. Eds. Greenhouse Gas Removal Technologies. Royal Society of Chemistry, 2022.

    - Cheng, J. Biomass to Renewable Energy Processes, 2nd Ed., Taylor and Francis, 2018.

    - Higman, C. and van der Burgt, M. Gasification, 2nd Ed., Elsevier, 2008.

    - Hodge, B. K. Alternative Energy Systems and Applications, Wiley and Sons, 2010.

    - MacKay, D. J. Sustainable Energy – Without the Hot Air, UIT Cambridge Ltd., 2009.

    - Niessen, W. R. Combustion and Incineration Processes, 4th Ed., CRC Press, 2010.

    - Santoleri, J. J., Reynolds, J., and Theodore, L. Introduction to Hazardous Waste Incineration, 2nd Ed., Wiley and Sons, 2000.

    - Tester, J. W., Drake, E. M., Driscoll, M. J., Golay, M. W., and Peters, W. A. Sustainable Energy: Choosing Among Options, 2 nd Ed, The MIT Press, 2012.

Course Structure

In summer 2026, this course is being offered as an online section. Lectures will be recorded and available on ELMS-Canvas under “Panopto Recordings/Video Lectures” by a set time each week.

Communication Guidelines

Communicating with the Instructor

My goal is to be readily available to you throughout the semester. I can be reached by email at patcaton@umd.edu, which is my preferred communication method. While I will do my best to respond to emails within 24 hours, you will more likely receive timely email responses from me during the work week. When constructing an email to me please put “ENPM XXXX (Section XXXX): Your Topic” in the subject line. This will draw my attention to your email and enable me to respond to you more quickly. If you don’t receive a response within a reasonable time, please feel free to follow-up with a text message to my cell phone, or give me a call between the hours of 1000-2300 hrs daily.

Additionally, please review These tips for 'How to email a Professor'. By following these guidelines, you will be ensured to receive a timely and courteous response.

Finally, if you need to discuss issues not appropriate for the classroom and/or an email, we can arrange to talk by phone, over Zoom, or in person. Send me an email asking for a meeting and we can set something up.

Announcements

I will send IMPORTANT messages, announcements, and updates through ELMS-Canvas. To ensure you receive this information in a timely fashion, make sure your email and announcement notifications (including changes in assignments and/or due dates) are enabled in ELMS-Canvas (How to change notification settings in CANVAS).

Log into our ELMs-Canvas course site at least once every 24-hour period to check your inbox and the Announcements page.

Names/Pronouns and Self-Identifications

The University of Maryland recognizes the importance of a diverse student body, and we are committed to fostering inclusive and equitable classroom environments. I invite you, if you wish, to tell us how you want to be referred to in this class, both in terms of your name and your pronouns (he/him, she/her, they/them, etc.). Keep in mind that the pronouns someone uses are not necessarily indicative of their gender identity. Visit trans.umd.edu to learn more.

Additionally, it is your choice whether to disclose how you identify in terms of your gender, race, class, sexuality, religion, and dis/ability, among all aspects of your identity (e.g., should it come up in classroom conversation about our experiences and perspectives) and should be self-identified, not presumed or imposed. I will do my best to address and refer to all students accordingly, and I ask you to do the same for all of your fellow Terps.

Communicating with your Peers

With a diversity of perspectives and experience, we may find ourselves in disagreement and/or debate with one another. As such, it is important that we agree to conduct ourselves in a professional manner and that we work together to foster and preserve a virtual classroom environment in which we can respectfully discuss and deliberate

controversial questions. I encourage you to confidently exercise your right to free speech—bearing in mind, of course, that you will be expected to craft and defend arguments that support your position. Keep in mind, that free speech has its limit and this course is NOT the space for hate speech, harassment, and derogatory language. I will make every reasonable attempt to create an atmosphere in which each student feels comfortable voicing their argument without fear of being personally attacked, mocked, demeaned, or devalued.

Any behavior (including harassment, sexual harassment, and racially and/or culturally derogatory language) that threatens this atmosphere will not be tolerated. Please alert me immediately if you feel threatened, dismissed, or silenced at any point during our semester together and/or if your engagement in discussion has been in some way hindered by the learning environment.

Netiquette Policy

Netiquette is the social code of online classes. Students share a responsibility for the course's learning environment. Creating a cohesive online learning community requires learners to support and assist each other. To craft an open and interactive online learning environment, communication has to be conducted in a professional and courteous manner at all times, guided by common sense, collegiality and basic rules of etiquette.

Grading

Grade Breakdown

Assignment	Percentage %
Homework	**35%**
Reading Quizzes on Paper Reviews	**35%**
Exams (2 x 15% each)	**30%**
Total	**100%**

Course Assignments

Homework Assignments

Six homework assignments will give students the opportunity to practice calculating:

- Exergy analysis for energy resources
- Comparisons of thermodynamic models to operational data to exergetic limits for common conversion technologies
- Carbon intensity of common energy pathways
- Decarbonization project

Paper Discussions

Four paper discussions will give students the opportunity to synthesize ideas from current relevant literature, and these will be assessed by timed but open-resource reading quizzes.

Exams

Two exams will be given during the term; one at the middle and one at the end of the term. Each exam will be composed of an open book but timed, conceptual portion and an open-resource analytical portion, both administered via the online ELMS-Canvas interface.

Class meetings will be split among the following tasks:

- Lecture-based explanation of concepts, often using lecture slides
- Questions on currently assigned homework
- Practicum session focused on specific examples, often using computer analysis, designed to help with the "how to's" of the upcoming assignments and paper reviews

Grading of Assignments

All assignments will be graded according to a predetermined set of criteria (i.e., rubric) which will be communicated to students before the assignment is submitted.

To progress satisfactorily in this class, students need to receive timely feedback. To that end, it is my intention to grade all assignments within one week of their due date. If an assignment is taking longer than expected to grade, students will be informed of when they can expect to see their grade.

Grade Computation

All assessment scores will be posted on ELMS/Canvas page. If you would like to review any of your grades (including the exams), or have questions about how something was scored, please email me to schedule a time for us to meet and discuss.

It is expected that you will submit work by the deadline listed in the syllabus and/or on ELMS-Canvas. Late work will be penalized according to the late work policy described in the **Course Policies and Procedures** section below.

Grade Disputes: I am happy to discuss any of your grades with you, and if I have made a mistake, I will immediately correct it. Any formal grade disputes must be submitted in writing and within one week of receiving the grade.

Final letter grades are assigned based on the percentage of total assessment points earned. To be fair to everyone I have to establish clear standards and apply them consistently, so please understand that being close to a cutoff is not the same as making the cut (89.99 ≠ 90.00). It would be unethical to make exceptions for some and not others.

Final Grade Cutoffs

Letter Grade	Cutoff
A+	97%
A	94%
A-	90%
B+	87%
B	84%
B-	80%
C+	77%
C	74%
C-	70%
D+	67%
D	64%
D-	60%
F	<60%

Course Schedule

Week #	Topic in Class	Assigned and Due Next Class
1	**I. Exergetic Resources on Earth** ● Interpret the energy flow diagram for Earth and exergetic Sankey diagrams for Earth. ● Establish standard units for measuring world-wide energy to build intuition. ● Review of thermodynamics.	**HW #1 –** Solar exergy to energy flux. **Reading:** Lindsey (2009) – global energy Balance. Hermann (2006) – global exergy resources. Review discussion questions before next class.
2	**II. Calculating Exergy** ● Review exergy calculations for main Earth resources (Hermann, 2006) ● Build tool for calculating material exergy ● and examine term-by-term contributions. **Practicum:** Discussion of Lindsey (2009). Calculations of solar exergy flux. Discussion of Hermann (2006). Calculating material exergy for separations.	**HW #2 –** Separation exergy for CO_2 capture. **Reading Quiz:** Lindsey (2009)
3	**III. Human Energy Demand** ● World and US national energy demand and CO_2 production. ● Population and GDP metrics suggest magnitude and location of future energy demand. **Practicum:** Calculating per capita energy and carbon dioxide emissions; projections to 2100.	**HW #3 –** Analyzing global energy demand and CO_2 emissions. **Reading:** Jones & Warner (2016) - population, energy, climate nexus.
4	**IV. Primary-to-Secondary Conversion** ● Primary-Secondary-Tertiary definitions and conversions with first and second law efficiencies. ● Compare natural and artificial solar conversion. ● Identify limiting and real best case conversion efficiencies for energy conversion. ● Using specific energy, energy density, and power density to distinguish resources. **Practicum:** Discussion of Jones & Warner (2016).	**Reading:** Aba et al. (2024) - hydrogen and electricity as carriers and storage in energy transition. **Reading Quiz:** Hermann (2006) and Jones & Warner (2016).
5	**IV. Primary-to-Secondary Conversion, continued** **Practicum:** Discussion of Aba et al. (2024). Estimating energy conversion pathway efficiency.	**HW #4 –** Estimates of fuel requirements to meet an energy requirement. **Reading Quiz:** Jones & Warner (2016) and Aba et al. (2024).
6	**V. Model of Energy Security** ● Articulate models of energy security from academic literature and how it has been quantified.	**Reading:** Sovacool (2012) – energy security challenges and needs. Review discussion questions before next class.

	● Explain recent examples of energy insecurity using a simple three-dimensional model. **Practicum:** Midterm review.	
7	**Midterm Exam: Sections I – V**	
8	**VI: Climate Science and Carbon Emissions** ● Describe the carbon balance on Earth and the imbalanced radiative forcing. ● Calculating carbon emissions from real resources using ultimate analyses and stoichiometry. ● Equivalent CO2 emissions. **Practicum:** Calculating carbon intensity. Discussion of Sovacool (2012).	**HW #5 –** Carbon emission calculations and exhaust carbon concentrations.
9	**VII: Clean Fossil Fuels** ● Why we love fossil fuels despite carbon cost. ● Motivation for, and technology behind CCS with case study. **Practicum:** Cost of adding CCS to coal plant.	**HW #6 –** Cost of adding CCS to coal plant
10	**VIII. Near-Zero Carbon Energy** ● Costs, carbon emissions, availability, grid integration of non-fossil fuel resources. ● How these resources promote security, or not.	**Reading:** Jacobson et al. (2015) – viability of full integration of wind, water, solar for US grid. Review discussion questions before next class.
11	**IX. Negative Emissions Technologies (NETs)** ● Motivation for negative emissions. ● DACCS, BECCS, ocean-based NETs, and other NETs: how it works, estimated cost, potential problems. **Practicum:** Biochar analysis. Discussion of Jacobson (2015).	
12	**Final Exam**	

Note: This is a tentative schedule, and subject to change as necessary – monitor ELMS-Canvas for current deadlines. In the unlikely event of a prolonged university closing, or an extended absence from the university, adjustments to the course schedule, deadlines, and assignments will be made based on the duration of the closing and the specific dates missed.

Course Policies and Procedures

The University of Maryland's conduct policy indicates that course syllabi should refer to a webpage of course-related policies and procedures. For a complete list of graduate course related policies, visit the Graduate School website. Below are course-specific policies and procedures which explain how these Graduate School policies will be implemented in this class.

Satisfactory Performance

The Graduate School expects students to take full responsibility for their academic work and academic progress. The student, to progress satisfactorily, must meet all the academic requirements of this course. Additionally, each

student is expected to complete all readings and any preparatory work before each class session, come to class prepared to make substantive contributions to the learning experience, and to proactively communicate with the instructor when challenges or issues arise.

Questions about Assignments

Please ask all questions you may have about an assignment by 1200 hrs (noon) the day before the assignment is due. Any questions asked after that time may not be answered in time for you to make changes to your work.

Late Work Policy

Assignments should be completed by the due date and time listed with the assignment, on the syllabus, and/or in the course calendar. If you are unable to complete an assignment by the stated due date, it is your responsibility to contact your instructor to discuss an extension, at least 24 hours BEFORE the assignment is due. Extensions are not guaranteed, but may be granted at the instructor's discretion.

Assignments submitted after a due date without consultation with the instructor and an agreed-upon extension will not be accepted. No assignment submitted after solutions have been posted will receive any credit, regardless of request for extension or status of that request.

Technology

Please refrain from using your cell-phone during class for any reason unrelated to class. Please use laptops only for following along with lecture notes or participating in practicums. If you need to conduct other business on your cell phone or computer, please quietly exit the room and return when you are ready.

Religious Observance

It is the student's responsibility to inform the instructor of any intended absences for religious observances in advance. Notice should be provided as soon as possible but no later than the end of the schedule adjustment period.

Academic Integrity

For this course, some of your assignments will be collected via Turnitin on ELMS/Canvas. I have chosen to use this tool because it can help you improve your scholarly writing and help me verify the integrity of student work. For information about Turnitin, how it works, and the feedback reports you may have access to, visit Turnitin Originality Checker for Students

The University's Code of Academic Integrity is designed to ensure that the principles of academic honesty and integrity are upheld. In accordance with this code, the University of Maryland does not tolerate academic dishonesty. Please ensure that you fully understand this code and its implications because all acts of academic dishonesty will be dealt with in accordance with the provisions of this code. All students are expected to adhere to this Code. It is your responsibility to read it and know what it says, so you can start your professional life on the right path. **As future professionals, your commitment to high ethical standards and honesty begins with your time at the University of Maryland.**

It is important to note that course assistance websites, such as CourseHero, or AI generated content are not permitted sources, unless the instructor explicitly gives permission. Material taken or copied from these sites can

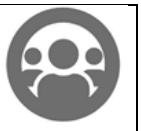
be deemed unauthorized material and a violation of academic integrity. These sites offer information that might be inaccurate or biased and most importantly, relying on restricted sources will hamper your learning process, particularly the critical thinking steps necessary for college-level assignments.

Additionally, students may naturally choose to use online forums for course-wide discussions (e.g., Group lists or chats) to discuss concepts in the course. However**, collaboration on graded assignments is strictly prohibited unless otherwise stated**. Examples of prohibited collaboration include: asking classmates for answers on quizzes or exams, asking for access codes to clicker polls, etc. Please visit the **Office of Graduate Studies' full list of campus-wide policies** and reach out if you have questions.

Finally, on each exam or assignment you must write out and sign the following pledge: ***"I pledge on my honor that I have not given or received any unauthorized assistance on this exam/assignment."***

If you ever feel pressured to comply with someone else's academic integrity violation, please reach out to me immediately. Also, ***if you are ever unclear*** about acceptable levels of collaboration, ***please ask***!

To help you avoid unintentional violations, the following table lists levels of collaboration that are acceptable for each graded exercise. Each assignment will contain more specific information regarding acceptable levels of collaboration.

Assignment Type	 OPEN NOTES	 READ BOOK	 LEARN ONLINE	 GATHER CONTENT WITH AI	 ASK FRIENDS	 WORK IN GROUPS
Homework	✔	✔	✔	No	✓	✓
Quizzes	✔	✔	✔	No	No	No
Final Exam	✔	✔	✓	No	No	No

Course Evaluation

Please submit a course evaluation through Student Feedback on Course Experiences in order to help faculty and administrators improve teaching and learning at Maryland. All information submitted to Course Experiences is confidential. Campus will notify you when Student Feedback on Course Experiences is open for you to complete your evaluations at the end of the semester. Please go directly to the **Student Feedback on Course Experiences** to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing through Testudo the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

Copyright Notice

Tips for Succeeding in this Course

1. **Participate.** I invite you to engage deeply, ask questions, and talk about the course content with your classmates. You can learn a great deal from discussing ideas and perspectives with your peers and professor. Participation can also help you articulate your thoughts and develop critical thinking skills.
2. **Manage your time.** Students are often very busy, and I understand that you have obligations outside of this class. However, students do best when they plan adequate time that is devoted to course work. Block your schedule and set aside plenty of time to complete assignments including extra time to handle any technology related problems.
3. **Login regularly.** I recommend that you log in to ELMS-Canvas several times a week to view announcements, discussion posts and replies to your posts. You may need to log in multiple times a day when group submissions are due.
4. **Do not fall behind.** This class moves at a quick pace and each week builds on the previous content. If you feel you are starting to fall behind, check in with the instructor as soon as possible so we can troubleshoot together. It will be hard to keep up with the course content if you fall behind in the pre-work or post-work.
5. **Use ELMS-Canvas notification settings.** Pro tip! Canvas ELMS-Canvas can ensure you receive timely notifications in your email or via text. Be sure to enable announcements to be sent instantly or daily.
6. **Ask for help if needed.** If you need help with ELMS-Canvas or other technology, IT Support. If you are struggling with a course concept, reach out to me and your classmates for support.

Student Resources and Services

Taking personal responsibility for your learning means acknowledging when your performance does not match your goals and doing something about it. I hope you will come talk to me so that I can help you find the right approach to success in this course, and I encourage you to visit the Counseling Center's Academic Resources to learn more about the wide range of resources available to you. Below are some additional resources and services commonly used by graduate students. For a more comprehensive list, please visit the Graduate School's Campus Resources Page.

Accessibility and Disability Services

The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The Accessibility & Disability Service (ADS) provides reasonable accommodations to qualified individuals to provide equal access to services, programs and activities. ADS cannot assist retroactively, so it is generally best to request accommodations several weeks before the semester begins or as soon as a disability becomes known. Any student who needs accommodations should contact me as soon as possible so that I have sufficient time to make arrangements.

For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301-314-7682, or email them at adsfrontdesk@umd.edu. Information about sharing your accommodations with instructors, note taking assistance and more is available from the Counseling Center.

Writing Center
Everyone can use some help sharpening their communication skills (and improving their grade) by visiting The Graduate School's Writing Center and schedule an appointment with them. Additionally, international graduate students may want to take advantage of the Graduate School's free English Editing for International Graduate Students (EEIGS) program.

Health Services
The University offers a variety of physical and mental health services to students. If you are feeling ill or need non-emergency medical attention, please visit the University Health Center.

If you feel it would be helpful to have someone to talk to, visit UMD's Counseling Center or one of the many other mental health resources on campus.

Notice of Mandatory Reporting
Notice of mandatory reporting of sexual assault, sexual harassment, interpersonal violence, and stalking: As a faculty member, I am designated as a "Responsible University Employee," and I must report all disclosures of sexual assault, sexual harassment, interpersonal violence, and stalking to UMD's Title IX Coordinator per University Policy on Sexual Harassment and Other Sexual Misconduct.

If you wish to speak with someone confidentially, please contact one of UMD's confidential resources, such as CARE to Stop Violence (located on the Ground Floor of the Health Center) at 301-741-3442 or the Counseling Center (located at the Shoemaker Building) at 301-314-7651.

You may also seek assistance or supportive measures from UMD's Title IX Coordinator, Angela Nastase, by calling 301-405-1142, or emailing titleIXcoordinator@umd.edu.
To view further information on the above, please visit the Office of Civil Rights and Sexual Misconduct's website at ocrsm.umd.edu.

Basic Needs Security
If you have difficulty affording groceries or accessing sufficient food to eat every day, or lack a safe and stable place to live, please visit UMD's Division of Student Affairs website for information about resources the campus offers you and let me know if I can help in any way.

Veteran Resources
UMD provides some additional supports to our student veterans. You can access those resources at the office of Veteran Student life and the Counseling Center. Veterans and active duty military personnel with special circumstances (e.g., upcoming deployments, drill requirements, disabilities) are welcome and encouraged to communicate these, in advance if possible, to the instructor.