MARYLAND APPLIED GRADUATE ENGINEERING

ENPM662: Energy Conversion I - Stationary Power (0101, ME01)

Term: *Fall 2023*
Professor: Patrick Caton, Ph.D., P.E.
Pronouns: He/Him
Cell Phone: 408-679-0352
Email: patcaton@umd.edu
Office Hours: Thursdays after class to 10:30pm and by arrangement

Credits: 3
Course Dates: From Aug 31, 2023 - Dec 7, 2023
Course Times: Thursday 7:00pm - 9:40pm
Classroom: TBD and Online

Canvas/ELMS: ###

Course Description

The global stationary power sector converts all sorts of energy resources into useful energy carriers, and mostly, that means electricity. It is a sector in flux. On the one hand, there is huge growth in solar and wind power, interest in capturing carbon, and other developments aimed at a low-to-zero carbon future. On the other hand, globally, stationary power still remains mostly driven by coal.

This course presents the scientific and engineering basis for modern stationary power plants that produce electricity, including conventional steam cycles, gas turbines and combined cycles, and nuclear plants; solar, wind, and hydroelectric power; and also, strategies to reduce carbon intensity such as gasification, IGCC, and carbon capture processes. These approaches will be discussed in terms of external costs (e.g. pollutants and carbon emissions), and integration into the electric grid. Students will design their own conventional power plant as well as their own "microgrid" to integrate various types of available power. The class emphasizes analysis and modeling using computer tools.

Prerequisites

Undergraduate courses in thermodynamics and heat transfer.

Learning Outcomes

After successfully completing this course you will be able to:

- Explain the most common resources for stationary power generation and the variety of methods of resource conversion that are used domestically and world-wide.
- Create effective models of conventional steam-cycle power plants and design a microgrid to utilize several available power sources.
- Compare and contrast the key technologies used for the most common stationary power cycles.
- Design a pollution control system for a combustion-based power plant.
- Evaluate how different types of stationary power systems contribute to a grid and predict the carbon intensity and pollutant intensity of the grid.
- Interpret trends in renewable power generation and formulate how possible future scenarios will encourage, or discourage, certain technologies.

Course Materials

Required Resources

- Book: T Weston, Kenneth. Energy Conversion, 2000, available online. https://www.academia.edu/37431526/Energy_Conversion_Kenneth_C._Weston_SECOND_EDITION_2000_)01-148_
- Application/Software: Students will be required to use computer software to complete assignments. Software will be available on the Virtual Computer Lab. The use of Engineering Equation Solver (EES) is strongly encouraged. Excel and MATLAB may also be helpful.

Supplemental Resources (no purchase required)

- None

Course Structure

This course includes both on-campus and online sections. To attend synchronously online, log into ELMS-Canvas at the time of the Section 0101 class on Thursdays at 7:00pm and select "Video Conference" from the left side menu. This will open a Zoom link to the live classroom.

For asynchronous online students, all lectures will be recorded and made available on ELMS-Canvas under "Panopto Recordings/Video Lectures" within 24 hours of the class time. Be sure to review the recorded lecture in a timely manner.

Students are expected to read assigned sections of the on-line textbook in advance of class and to come prepared to
ask questions. Online students, be sure to log into Canvas regularly and participate in discussions and activities. Regardless of the section you are enrolled in, participation is expected.

Please note that F1 students enrolled in the on campus section are required to attend in person. If you have a conflict on a particular day, please reach out to me in advance to discuss.

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. I will do my best to respond to emails within 24 hours; if you do not receive a response in that time, please resend your email in case it was missed or use my cell phone.

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.

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	**20%**
Design Projects	**30%**
Exams (2)	**50% (25% each)**
Total	**100%**

Course Assignments

Homework Assignments

- Seven homework assignments will enable students to practice quantitative and qualitative analysis related to energy conversion systems.

Design Projects

- Two design projects will allow students to explore cycle design using the Engineering Equation Solver software or Excel and evaluate candidate cycles.

Final Exam

- 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 a timed conceptual portion and an open-resource analytical portion, both administered via the online ELMS-Canvas interface.

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 **1 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. It would be unethical to make exceptions for some and not others.

Final Grade Cutoffs									
+	98.00%	+	88.00%	+	78.00%	+	68.00%	+	
A	92.00%	B	82.00%	C	72.00%	D	62.00%	F	<60.0%
-	90.00%	-	80.00%	-	70.00%	-	60.00%	-	

Course Schedule

Week	Topic Today in Class	Assignment for Next Class
1 8/31	**I. Energy, Exergy, and Climate** ● Interpret the energy flow diagram for Earth and exergetic Sankey diagrams for Earth. ● Establish standard units for measuring world-wide energy to build intuition. ● Examine stationary power in national and global energy flows **Practicum:** Introduce computer modeling tools.	**HW #1** – Evaluate predictions of DOE Annual Energy Outlook regarding stationary power. **Reading:** Weston, Ch. 1. Review discussion questions before next class.
2 9/7	**II. Thermodynamics for Stationary Power** ● Review application of First and Second Law energy and entropy balances to open systems. ● First and second law efficiencies of reactive and heat engines. ● Limit substances: ideal gas and incompressible liquids. ● State diagrams: two phase region and vapor dome. ● Using component efficiencies to analyze performance. **Practicum:** Computer modeling and analysis tool demonstration.	**HW #2** – Practice property evaluation and basic thermodynamic analysis using ideal gases, efficiencies, and component analysis. **Reading:** Weston, Section 4.5. Review discussion questions before next class.
3 9/14	**III. Economics for Stationary Power** ● Time value of money and conversions among present, ongoing, and future costs. ● Introduction to lifecycle analysis and LCOE/LACE of various resources and technologies.	**HW #3** – Practice engineering economic cost analysis. **Reading:** Weston, Ch. 3. Review discussion questions before next class.

	● Economic principles of finite resources. **Practicum:** Time value of money conversions and analysis.	
4 9/21	I**V. Fossil Fuels and Combustion** ● Composition of fossil fuels with proximate, ultimate, and energy content analysis. ● Evaluating stoichiometry and energy release of fossil fuels. ● Evaluating emissions from fossil fuels. ● Technology for burning fossil fuels including typical "air flow path" in stationary power plant. **Practicum:** Stoichiometry, emissions, and parametric calculations using computer tools.	**HW #4** – Emissions from burning fossil fuels and peak combustion temperatures. **Reading:** Weston, Sections 2.1 – 2.6 and 4.1 – 4.4. Review discussion questions before next class.
5 9/28	**V. Steam Power Cycles** ● Rankine cycle analysis with regeneration. ● Technology for building a steam power cycle include the "water path" in a typical stationary power plant. ● Interpreting power cycle performance using state diagrams. **Practicum:** Rankine cycle modeling and analysis using computer tools.	**HW #5** – Rankine cycle analysis. **Reading:** Weston, Sections 5.1-5.7, 9.2-9.3, 9.8. Review discussion questions before next class.
6 10/5	**VI. Gas Turbines and Combined Cycles** ● Thermodynamics of the Brayton cycle and interpretation of performance using state diagrams. ● Design of a modern gas turbine engine. ● Motivation for combined cycles; comparison of performance of combustion turbines with combined cycles. **Practicum:** Discussion and setup of design project #1.	**Design Project #1** – Design and optimize a steam-based power cycle. Part 1 due week 7; part 2 due week 8. **Reading:** Weston, Ch. 10. Review discussion questions before next class.
7 10/12	**VII. Nuclear Power** ● Basic physics underlying nuclear fission and fusion. ● Fissile, fissionable, and fertile species. ● Design of PWR, BWR, heavy water, fast neutron, Breeder configurations. ● Comparison and contrast of nuclear cycles with steam cycles, including direct costs, external costs, and influence of key accidents on public perception. **Practicum:** Discussion of design project #1; regenerative Rankine cycle modeling.	Prepare for Exam 1 and complete Design Project #1.
8 10/19	**Exam 1**	**Reading:** Weston, Section 11.5. IPCC (2011) Renewable Energy Sources:

		Geothermal (4.1, 4.3). Review discussion questions before next class.
9 10/26	**VIII. Solar and Geothermal Power** ● Technology and performance of solar and geothermal power systems. ● Peak sun hour method for solar installation design. **Practicum:** Peak sun hour method for solar design.	**HW #6** – Sizing a solar array. **Reading**: IPCC (2011) Renewable Energy Sources: Wind (7.1, 7.3.1-7.3.1.3, 7.5.1) and Hydro (5.1, 5.3).
10 11/2	**IX. Wind and Hydroelectric Power** ● Technology and performance of wind and hydroelectric power systems. ● Pumped storage. ● Estimating performance of a wind turbine. **Practicum:** Estimating performance of a wind turbine.	**HW #7** – Estimating performance of a wind turbine installation. **Reading**: NREL, Microgrids for Energy Resilience (Section 1); NREL "Understanding Inertia Without the Spin" (video)
11 11/9	**X. Grid Integration and Microgrids** ● Typical demand on grid and duck curve; how demand is often met with different types of power. ● Microgrid design. **Practicum:** Discussion and demonstration of microgrid.	**Design Project #2** – Microgrid design. Due Week 14. **Reading**: IPCC (2011) Renewable Energy Sources: Bioenergy (2.1, 2.2, 2.3)
12 11/16	**XI. Biomass and Waste** ● Availability and energy content of biomass and waste. ● Benefits and challenges of these resources. ● Compare and contrast plant design with coal-fired plant. **Practicum:** Microgrid design discussion.	**Design Project #2** – Microgrid design. Due Week 14.
13 11/23	No Class due to Thanksgiving Holidays	
14 11/30	**XII. Pollutant and Carbon Abatement** ● Clean air act and definition of pollutants. ● Technologies and approaches to avoid, or abate, pollutants from fossil fuel combustion.. ● Carbon capture and storage and negative emissions technologies. **Practicum:** Course review and questions.	Prepare for Exam 2.
15 12/7	**Exam 2**	

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 9:00 AM 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.

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 straight away. 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.

						
Homework Assignments	✓	✓	✓	---	✓	---
Design Projects	✓	✓	✓	---	✓	---
Exams	✓	✓	---	---	---	---

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
Course materials are copyrighted and may not be reproduced for anything other than personal use without written permission.

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.