Division of Engineering and Mathematics
School of Science, Technology, Engineering, and Mathematics
University of Washington Bothell

B EE 381 Electric Power Generation

Time and Location: Mon/Wed 3:30 - 5:30 pm in DISC 362

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Canvas Homepage: https://canvas.uw.edu/courses/1151810

Course Description

This course provides an introduction to energy conversion and power generation, with a focus on electric power. It combines elements of electrical and mechanical engineering, along with economics and public policy, to develop understanding of how electric power systems generate electricity, transmit, and distribute it to end users.

Electric power today is still mostly generated in thermal power plants that use steam or hot combustion gases to drive large turbines. These turbines in turn spin generators that, through electromagnetic induction, convert mechanical energy into alternating current. After stepping up the voltage, the power plant delivers its output onto the local electricity grid, where it is almost always immediately consumed by users served by the grid. In the Pacific Northwest and a few other regions blessed with abundant rainfall and snowmelt, large hydroelectric facilities use falling water to spin the turbines that power the generators. Because hydroelectric plants produce mechanical work without first producing heat, they are more efficient than thermal plants, and produce fewer pollutants, though they disrupt ecosystems in other ways.

In recent years, wind and solar energy have grown quickly. More than 60 percent of all new power generating capacity brought on line in the US in 2016 was wind or solar. Last December, wind power generating capacity for the first time surpassed hydroelectric capacity in the US. Non-hydro sources now supply more than nine percent of electric power generation in the US, and that figure will only climb as costs of electricity from solar and wind continue to fall. Even so, thermal power generation from coal, natural gas, and nuclear plants still account for more than 80 percent of total capacity. Over the past decade, hydraulic fracturing (“fracking”) technology has opened up vast new supplies of natural gas in the US. With abundant supplies of fuel, historically low fuel prices, and an Administration in Washington, DC, supportive of the fossil fuel industry, thermal power generation will continue to be the primary source of utility-scale electric power for many years to come.

Most electric power courses deal only with the electrical side of power plants. This course is different. Although it covers fundamentals of electric power circuits, the chemical and mechanical processes involved in energy conversion are also emphasized. Economics of power plants, operation and control of the grid, and dynamics of electricity markets are considered, as well. A society's use of technology is shaped not only by technological factors. In the energy sector, and electricity in particular, politics and economics constantly alter the incentives generators and utilities face, slowing the rollout of some technologies even as they accelerate deployment of others. Readings and assignments covering the non-technical aspects of power generation serve as reminders that engineers work in a context that is influenced as much by technological innovation as it is by economics and politics.

Learning Outcomes

After completing the course, students will be able to:

1. Compare and evaluate power generation technologies in terms of the underlying science, engineering, economics, and environmental impact.

2. Describe the operation of an electric power system in terms of its deployable resources, market structure, load balancing, and control.

3. Analyze wind, solar, fuel cells, and other renewable energy resources, and evaluate their potential to be integrated economically and sustainably into the electric power grid.

4. Analyze and describe AC power produced in the generation process, including its application in three-phase systems, generators and motors, transformers, and transmission systems.

5. Identify and evaluate economic, political, and regulatory factors that govern the generation, transmission, and distribution of electric power.

Required Materials

Textbook: Mohamed A. El-Sharkawi, ***Electric Energy: An Introduction*** (CRC Press, 2013). Other readings will be made available in Canvas as needed.

Engineering Paper and Pencils: Unless otherwise instructed, all work submitted during this class must be done on green engineering paper, in pencil, on one side only.

Canvas: Course materials and assignments will be posted on Canvas, which is the campus' online course management system. Grades on individual assignments are posted in Canvas as they become available. Please be aware that I do not use Canvas to calculate the course grade in real time. The Canvas homepage is https://canvas.uw.edu/courses/1151810
Enrollment in Canvas is automatic with your course registration. You will need your UWNetID to log into Canvas. For help with Canvas, see the following UWB page:
http://www.uwb.edu/learningtech/elearning/canvas/canvas-for-students

Assignments

Homework (20%), assigned most weeks in Canvas. Homework will normally be due on Mondays, 5-7 days after it has been posted. Homework problems must be worked in pencil on green engineering paper; all work must be clearly shown, and the answers highlighted. Some questions may require a response in the form of a paragraph or short essay, in which case the answer should be word-processed, printed, and stapled to the other pages. Solutions will be posted in Canvas within a day or two of the homework due date.

Midterm Exam (25%) and Comprehensive final exam (25%). Two-hours, in class. The midterm exam is on April 26 and covers the first half of the course. The final exam, on June 5, is comprehensive but emphasizes the material from the second half of the course. Exams consist of multiple choice, short-answer questions, true-false questions, and problems.

News Briefs (10%): On most Wednesdays (and one Monday in May) we'll devote the first 10-15 minutes of class to a discussion of current news, policy, and issues in power generation, transmission, and distribution. Students bring to class a one-page (200-250 word, double-spaced, in 12-point Times New Roman font, one-inch margins all sides, name and date at top) brief of a news item that captured their attention that week. Each brief should have two paragraphs: the first summarizes the news item, the second explains why you think it's interesting and important. I'll call on one or more students to share their news item and collect all briefs at the end of the discussion. News items must be chosen from the following sources:

- Power Magazine (http://www.powermag.com/): electric power business/technology news
- Utility Dive (http://www.utilitydive.com/): covers the electric power utility sector
- Power Engineering (http://www.power-eng.com/index.html): general power industry news; of special interest is the Power Engineering Newscast accessible from home page.
  a video summary of the day's news is at
- IEEE Spectrum Energy News (http://spectrum.ieee.org/energy): global energy news
- Renewable Energy World (http://www.renewableenergyworld.com): renewable energy news
- Greentech Media (https://www.greentechmedia.com/): news on green/clean energy

Classwork (5%), Worksheets done in class, individually or in small groups. Exercises relate to course readings and topic of the day, and may include problems, fill-in blank questions, multiple choice questions, and short essays.

Sustainable energy project (15%), For this, you will work in teams of four, organized by the end of the second week. I will organize the teams which, to the extent possible, will include at least one EE and one ME student.

> Your charge: develop a proposal for a low-carbon or carbon-free power generation system for the UW Bothell campus that will enable the campus to meet its 2050 climate-neutral goals, and present it to the UWB Facilities team. In this, you will work closely with Ms. Cassie Lubenow, the campus Sustainability Officer, your instructor, and other members of Ms. Lubenow's staff as may be required. The campus already meets a small part of its electricity needs from solar panels mounted at various locations. But most of our energy still comes by way of local natural gas pipeline and the electricity grid, through the services of our local investor-owned utility Puget Sound Energy. You will investigate the options, which might include additional solar arrays, combined heat and power (C&P) using hydrogen or natural gas-fired microturbines, wind turbines, micro-hydro systems, waste-to-energy systems that digest or burn garbage and/or organic waste, internal combustion engines, batteries and other storage technologies.

Your deliverable: A design proposal that includes a written description of the system, drawings, supporting calculations, and rough cost estimate. There are no right answers, and many unknowns. You will have to make many assumptions (and that's good as long as you justify them!). This is real-world engineering, similar to what you will be expected to do when you start your engineering career. However, you are still learning, and we have only a few weeks; we therefore expect only a roughed-out design. Your written report should be 8-12 pages in length, including drawings, calculations, equipment list equipment, and bibliography at the end that lists sources used in your research. (If you have not yet used the library for engineering research, now's a good time to start: Ms. Penelope Wood, our engineering librarian, will be happy to assist.) On the last day of class, you will pitch your proposal to the class in a short (10-minute) oral presentation, at which members of our Facilities team will be present.

Policies and Campus Resources

Classroom Conduct and Etiquette: Maintaining a productive learning environment requires everybody's cooperation. Use of cell phones, laptops, tablets, and other devices for purposes unrelated to the class will not be permitted. Be in class on time, and stay until the end.

Communications by email: You may email me through Canvas. However, because I check my UW email more often using Outlook, you will probably receive a quicker reply by emailing outside Canvas at swcollin@uw.edu. Please allow 24 hours for email replies weekdays (though usually I can respond within 12 hours), and 36 hours on weekends.

Absences and missed assignments: Classwork must be done in class when it is assigned; it will not be accepted late. Homework and other assignments done outside of class will normally be penalized 0.5 grade points for each day after the due date, unless I'm convinced there is a good reason for it. Exams missed without prior arrangements may be made up only in the event of a grave emergency that must be documented and explained to my satisfaction. Should work-related travel or another important event prevent you from taking an exam at the scheduled time, bring it to my attention at least two weeks before the scheduled day of the exam; it may be possible to take the exam early, at a place and time of my choosing.

Grading: Grades are recorded on a 4-point scale, in accordance with UW policy. I generally use the following conversion from a 100-point scale to the 4-point scale: 99-100=4.0, 97-98=3.9, 95-96=3.8, 93-94=3.7, 91-92=3.6, 90=3.5, 89=3.4, 88=3.3, 85=3.0, 82=2.7, 80=2.5. In exceptional circumstances, grades may be curved using the appropriate statistical measures. More information on the UW grading system can be found here:
http://www.washington.edu/students/gencat/front/Grading_Sys.html

Incompletes: University rules state that "an incomplete is given only when the student has been in attendance and has done satisfactory work until within two weeks at the end of the quarter and has furnished proof satisfactory to the instructor that the work cannot be completed because of illness or other circumstances beyond the student's control."

Academic integrity: Students are responsible for knowing what constitutes a violation of the University of Washington Student Code, and they will be held responsible for any such violations whether they were intentional or not. The standards for student conduct and procedures for dealing with misconduct are prescribed in the Student Conduct Code for the University of Washington (http://app.leg.wa.gov/wac/default.aspx?cite=478-120). Issues concerning academic integrity and misconduct are handled by Student Affairs, with information available here: http://www.uwb.edu/studentaffairs/studentconduct.

Plagiarism is a serious academic offense. You should recognize it (see "What is Plagiarism?" at http://libguides.uwb.edu/content.php?pid=87430&sid=691950) and take strategies to avoid it in your own writing (see "Strategies for Avoiding Plagiarism" at http://libguides.uwb.edu/content.php?pid=87430&sid=691952). If I suspect that an assignment has been plagiarized, I will confront the student and ask for an explanation. Possible sanctions include failure on the assignment and reporting to Student Affairs.

Respect for Diversity: Diverse backgrounds, embodiments and experiences are essential to the critical thinking endeavor at the heart of university education. Students are expected to respect individual differences which may include, but are not limited to: age, cultural background, disability, ethnicity, family status, gender presentation, immigration status, national origin, race, religious and political beliefs, sex, sexual orientation, socioeconomic status, and veteran status. Students seeking support around these issues can find more information at http://www.uwb.edu/diversity.

Access and Accommodations: Your experience in this class is important to me. If you have already established accommodations with Disability Resources for Students (DRS), please communicate your approved accommodations to me at your earliest convenience so we can discuss your needs in this course.

If you have not yet established services through DRS, but have a temporary health condition or permanent disability that requires accommodations (conditions include but not limited to; mental health, attention-related, learning, vision, hearing, physical or health impacts), you are welcome to contact DRS at 425-352-5307 or uwbdrs@uw.edu. DRS offers resources and coordinates reasonable accommodations for students with disabilities and/or temporary health conditions. Reasonable accommodations are established through an interactive process between you, your instructor(s), and DRS. It is the policy and practice of the University of Washington to create inclusive and accessible learning environments consistent with federal and state law.

For Our Veterans: If you are a student who has served in our nation's military forces, thank you for your service. I hope that you feel comfortable enough to confidentially self-identify yourself to me so I can help you make a successful transition from the military to higher education.

Class cancellation and inclement weather policy: Should illness, inclement weather, or other unexpected event require me to cancel a particular class meeting, I will post an announcement on Canvas at the earliest opportunity.

Support for Students: UW Bothell provides a wide range of services to assist students with academic, career, and personal matters.

Academic Advising for Engineering: Charlotte Emigh at cemigh@uw.edu, 425-352-3746
Counseling Center: http://www.uwb.edu/studentaffairs/counseling, UW1-080, 425-352-3183
IT Helpdesk: IT@uwb.edu, 425-352-3456
Library: www.uwb.edu/library, 425-352-5340. The engineering research librarian is Penelope Wood, who can be reached at woodpd@uw.edu or 425-352-3467.
Quantitative Skills Center: http://www.uwb.edu/qsc, UW2-030, 425-352-3170.
Student Success Center: http://www.uwb.edu/studentsuccesscenter, 425-352-3427
Writing and Communication Center: http://www.uwb.edu/wacc, UW2-124, 425-352-5253

Schedule

Date	Topic	Readings	Assignment
3/27	1. Overview 2. Electricity Basics	• "Electricity Fundamentals" (Handout)	
3/29	1. Intro to Project 2. History of the Grid and Current Structure	• Textbook, Chapters 1and 2 (all) • "FERC Primer 1" (Canvas)	News Brief 1
4/3	1. Energy Sources 2. Hydro Power	• Textbook, Chapter 3 (all) • Textbook, Chapter 4 (pp. 53-70) • Textbook, Chapter 5 (pp. 158-178)	Homework 1
4/5	Thermal Power Generation	• Textbook, Chapter 4 (pp. 70-86) • "Thermal Generation" (Canvas)	News Brief 2
4/10	1. Environmental Impacts 2. Power Plant Economics	• Textbook, Chapter 5 (all) • "Economic Analysis" (Canvas)	Homework 2
4/12	Solar Power	• Textbook, Chapter 6 (pp. 99-128) • "PV-Powered Water Pumping" (Canvas)	News Brief 3
4/17	Wind Power	• Textbook, Chapter 6 (pp. 133-158) • "Economics of Solar and Wind" (Canvas)	Homework 3
4/19	1. Geothermal Power 2. Biomass Power	• Textbook, Chapter 6 (pp. 178-187) • "Bioenergy" (Canvas)	News Brief 4
4/24	1. Fuel Cells and Storage 2. Combined Heat and Power	• Textbook, Chapter 6 (pp. 187-209) • "Combined Heat and Power" (Canvas)	Homework 4
4/26	**Midterm Exam (in class)**		Midterm Exam
5/1	Single-Phase AC Power	• Textbook, Chapter 7 (all)	
5/3	Three-Phase Power	• Textbook, Chapter 8 (all)	News Brief 5
5/8	1. Power Line to Wall Outlet 2. Transformers	• Textbook, Chapter 9 (pp. 293-310) • Textbook, Chapter 11 (all)	Homework 5
5/10	Electric System Operations	• "FERC Primer 2" (Canvas) • "Inside the Control Room" (Canvas)	News Brief 6
5/15	Motors and Generators	• Textbook, Chapter 12 ((pp. 395-451)	Homework 6
5/17	Electricity Markets	• "Energy Primer" (Canvas)	
5/22	Power Grid and Blackout	• Textbook, Chapter 14 (all)	News Brief 7
5/24	Toward an Efficient, Reliable, and Sustainable Grid	• Textbook, Chapter 15 (pp. 541-545) • "Top Trends" (Canvas)	Homework 7

Date	Topic	Readings	Assignment
5/29	MEMORIAL DAY - NO CLASS		
5/31	Project presentations Wrap up		Projects due
6/5	**FINAL EXAM (in class)**		Final Exam

Two optional field trips are planned. The first is to Snoqualmie Falls Hydroelectric Project[1] on Friday, May 5 (starting at 11 am). The second is to Puget Sound Energy's Frederickson 1 Generating Station, a 250 MW natural gas combined cycle thermal power generation plant near Tacoma[2], at a date still to determined but likely to be a Friday in late April to mid May. Students who participate in one or both field trips will have the opportunity to describe what they learned for extra credit on the final exam.

[1] https://pse.com/aboutpse/Facilities/Pages/Snoqualmie-Falls.aspx

[2] https://pse.com/aboutpse/PseNewsroom/MediaKit/067_Frederickson.pdf