The Electric Grid: Technology and Policy

Jeremy Lin

(Fall 2019: September 4, 2019 – December 17, 2019)

Note: Some adjustments may be made to this syllabus prior to the first class

I. Instructor, Course Information & Objectives

Instructor:
Dr. Jeremy Lin is Director at Transmission Analytics Consulting LLC. He can be contacted by phone {484-356-3925} or by e-mail {jlin137@jhu.edu}. E-mails received will be answered within 24-48 hours.

Course Description:
This course aims to introduce the students with an overview of electric power industry including the fundamentals of power system generation, transmission, and markets. Various power generation technologies and system network characteristics will be introduced. Key elements of power system operation such as unit commitment, economic dispatch, and optimal power flow will be discussed to provide the background for understanding how the power grid operates and to lay the foundation for understanding the environmental impact from power generation and system operation. An overview of grid planning will be provided. Students will also be exposed to power markets and complex relationship between market and system. Later, students will be exposed to the topics of US energy policy that particularly pertains to power industry. Relevant energy policies of certain countries on global setting for the electricity sector will also be discussed. The latest developments in power industry such as smart grid, microgrid, distributed energy resources and other topics will also be covered. Prior knowledge of optimization is helpful.
Course Goals and Learning Outcomes

By the end of this course, students will be able to:

- Describe and explain the fundamentals of power system, its components, and operation
- Assess the environmental impact of power generation and identify various approaches to mitigate that impact
- Explain how the grid is planned and how the power market operates
- Identify the various energy policies - domestic and international – that can help shape the future of power industry
- Analyze the emerging developments, and issues in power industry

Teaching Style:

The course will be delivered primarily through the online modules, reading assignments, homework, discussions, and final project.

This course will be comprised of 12 modules/lessons. Each Module will include a number of recordings (Panopto videos) of lectures by the instructor. The slides presented in these lectures will be available on Blackboard on the relevant lecture weeks.

In addition to regular homework and reading assignments, there will be one mid-term exam and final project. **There is no final exam.** For the final project, 3 to 4 students can form a project group to work on a specific topic. Each project group will be able to select the preferred topics but needs the approval from the instructor before initiating the work. The project topic selection and instructor approval should be sought during the earlier sessions of the course well before the mid-term or preferably at the beginning of the course. Once the final project topic is finalized and approved by the instructor, students in the project group will work on the chosen topics throughout the course. Student groups will produce both term paper and recorded video presentation for the final project. These products are intended to be vehicles for learning both content and skills that will be useful outside the classroom. See section “IV: Final Project” for both details and possible topics.

Please review the course syllabus thoroughly to learn about specific course outcomes and requirements.
II. Course Materials

Readings


- **Recommended Books**:

- **Other**: Other reading materials may be provided on the course Blackboard site, under the “Readings” tab and online hyperlinks (accessed via the online version of the Syllabus on the course Blackboard site, under the “Syllabus” tab).

Specific Technology Requirements & Skills for this Course

Students need to be able to:

- Navigate in and use Blackboard; the Blackboard Student Orientation course on your "My Institution" page
- Create and save MS Word documents; see MS Word training and tutorials for PC users (all versions); Word Help for Mac users
- Find basic resources on the Internet
- Create and organize files & folders on your computer
- Send, receive, and manage email
### III. Classes, Topics, and Activities

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<tr>
<th>Module</th>
<th>Title</th>
<th>Topics</th>
<th>Assignments</th>
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- Power System Basics  
- Electricity Industry Restructuring in the US and around the World  
- System Reliability as the Ultimate Goal | - Chapter 1 [Textbook]  
- Module 1 Discussion  
- Module 1 Questions (just credit only) |
- Thermal and Hydro Generators  
- Renewable Energy Sources (RES)  
- Distributed Generators | - Chapter 2 [Textbook]  
- Chapter 2 [Wood and Wollenberg]  
- Chapters 1-7 [Gharehpetian and Mousavi]  
- Module 2 Assignment (100 points) |
- Transmission Lines and Transformers  
- Network Characteristics and Models  
- Network Analysis (Power Flow Analysis)  
- Control of Power Flow | - Chapter 2 [Textbook]  
- Chapter 4 [Wood and Wollenberg]  
- Module 3 Discussion  
- Module 3 Assignment (100 points) |
- Unit Commitment (UC)  
- Numerical Methods (Heuristics, Dynamic Programming, Dual Methods, MIP) | - Chapter 4 [Textbook]  
- Chapter 5 [Wood and Wollenberg]  
- Module 4 Discussion  
- Module 4 Assignment (100 points) |
- Mathematical Formulation of ED Problem  
- Numerical Methods (Lambda Iteration, Newton Raphson, Reduced Gradient)  
- Transmission Loss | - Chapter 5 [Textbook]  
- Chapter 3 [Wood and Wollenberg]  
- Module 5 Discussion  
- Module 5 Assignment (100 points) |
- Solution Methods for OPF Problem | - Chapter 6 [Textbook]  
- Chapter 13 [Wood and Wollenberg] |
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<tr>
<th>Date Range</th>
<th>Topic</th>
<th>Subtopics</th>
<th>Assignments</th>
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| Oct 15 | Optimal Power Flow | • OPF Applied to Competitive Electricity Markets | • Module 6 Discussion  
• Module 6 Assignment (100 points) |
| Oct 16 – Oct 22 | Mid-Term (Module 1-6) | &nbsp; | &nbsp; |
| Oct 23 – Oct 29 | Environmental Aspect of Power Grid | • Emissions from Fossil-Based Power Generation  
• Renewable Energy Sources  
• Renewable Portfolio Standards  
• Emission Markets  
• Carbon Pricing | • Chapter 11 [Textbook]  
• Additional Readings  
• Module 8 Discussion  
• Module 8 Assignment (100 points) |
| Oct 30 – Nov 5 | Electricity Market I | • Electricity Market Basics  
• Market Design and Operation  
• Day-Ahead Energy Market  
• Real-Time Energy Market  
• Locational Marginal Price (LMP) | • Chapters 7 and 8 [Textbook]  
• Additional Readings  
• Module 9 Discussion  
• Module 9 Assignment (100 points) |
| Nov 6 – Nov 12 | Electricity Market II | • Financial Transmission Rights (FTR)  
• Capacity Market  
• Ancillary Service Market  
• Emerging Issues in Electricity Markets | • Chapter 7 [Textbook]  
• Additional Readings  
• Module 10 Discussion  
• Module 10 Assignment (100 points) |
| Nov 13 – Nov 19 | Grid Planning | • Transmission planning  
• Integrated Resource Planning (IRP)  
• System Planning under Market Regime  
• Economic-Based Transmission Planning  
• Competitive Transmission Planning | • Chapters 10 [Textbook]  
• Additional Readings  
• Module 11 Discussion  
• Module 11 Assignment (100 points) |
• Federal and State Policies  
• Global Energy Policies | • Various Readings  
• Module 12 Discussion  
• Module 12 Questions (just credit only) |
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<tbody>
<tr>
<td></td>
<td>- Smart Grid and Microgrid</td>
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<td>- Demand Response, Storage, and Electric Vehicles</td>
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<td></td>
<td>- Distribution System Operator (DSO)</td>
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<td>- Other Emerging Developments</td>
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<td>- Chapter 11 [Textbook]</td>
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<td>- Additional Readings</td>
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<td>- Module 13 Discussion</td>
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<td>- Module 13 Questions (just credit only)</td>
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<th>[14] (Dec 11 – Dec 17)</th>
<th>Final Project</th>
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<td>- Final Project Paper and Recorded Video Presentation are due</td>
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IV. Final Project

For the final project, 2 to 4 students will form a project group to work on a specific topic. Each project group will be able to select the preferred topics but needs the approval from the instructor before initiating the work. The project topic selection and instructor approval should be sought during the earlier sessions of the course well before the mid-term or preferably at the beginning of the course. Once the final project topic is finalized and approved by the instructor, students in the project group will work on the chosen topics throughout the course. Student groups will produce both term paper (double-spaced, about 15-20 pages) and recorded video presentation for the final project. These products are intended to be vehicles for learning both content and skills that will be useful outside the classroom. Potential topics, in either US or international context, are suggested below. Students can choose their preferred topics of their own, subject to instructor approval. Topics related to the latest and emerging issues of the course topics, are favorably preferred but not limited.

1. Electricity Industry Restructuring
2. Power Generation Technologies
3. Power Grid
4. Advanced Numerical Methods Applicable to Power Systems
5. Advanced Optimization Methods Applicable to Power Systems
6. Climate Change Impact by Power Generation and Remedies
7. Electricity Markets
10. Smart Grid, Microgrid, New Resources,
V. Grading

Each assignment will be evaluated using a numbered grade (0-100) and your overall numbered grade will be determined using the following weights:

- Assignments: 20%
- Participation: 10%
- Mid-Term: 30%
- Final Project: 40%

Letter grades of A, A-, B+, B, B-, C+, C, C-, or F will be assigned according to numbered grades in the following way:

- Above 100: A+
- (95-100]: A
- (90-95]: A-
- (85-90]: B+
- (80-85]: B
- (75-80]: B-
- (70-75]: C+
- (65-70]: C
- (60-65]: C-
- 60 or below: F

**Participation.** You are expected to prepare for class by reviewing the assigned readings, and materials discussed in previous classes.

**Policy on late assignments.** Most assignments will be posted before Friday of the specific week of the module, after the lecture modules are posted. The related assignments are due until the following Sundays at 11:59PM. Late assignment will not be accepted, so please plan to submit a few hours before the acceptance date/time. Also, double check that your submission contains the right files, and resubmit it if anything is missing. Poor grades due to missing files or files submitted by mistake will not be reconsidered.

**There are no make-up assignments, please do not ask.**

If you are in true emergency which prevents you from completing your assignments, send an email to me as soon as possible.
Policy on class participation. Several opportunities for participating in class will be provided online. For most modules, topical materials for discussion will be provided. The materials can be news, articles, technical papers, etc.

Everyone is expected to participate in online discussion. Occasionally additional credits may be given for answering challenging questions during online discussion. In those cases, the grade from participation and attendance may rise above 100%.

VI. Course Participation & Communication Policy

Participation

What are the participation requirements?
You are expected to log into Blackboard at least three times a week, though a daily check-in is recommended.

It is your responsibility to read all announcements and discussion postings within your assigned forums.

You should revisit the discussion multiple times over the week to contribute to the dialogue and review feedback from your peers.

Each discussion forum prompt requires an initial (primary) post and one or more substantive response (secondary) posts.

Posting details and requirements are further specified in each discussion prompt's directions.

There may be one or more discussion prompts per weekly discussion. I will be reading your posts daily, but I generally refrain from directly commenting on most posts (unless you specifically address a question to me).

I will occasionally interject to guide the conversation back on track, to connect student ideas, and to share examples that deepen your understanding.

For the most part, the discussion area is intended for you and your peers to discuss and debate the lesson topic, readings, activities, and themes. I recognize that frequent posts from me tend to distract and stifle rich student conversation.
Network Etiquette (i.e. “Netiquette”)

In this course, online discussion will be primarily take place in our online discussion board. In all textual online communication, it’s important to follow proper rules of netiquette.

What is netiquette? Simply stated, it's network etiquette -- that is, the etiquette of cyberspace. And "etiquette" means the social and cultural norms of communicating with others in a proper and respectful way. In other words, netiquette is a set of rules for behaving and interacting properly online.

The Netiquette “Core Rules” linked below are a set of general guidelines for cyberspace behavior. They probably won't cover all situations, but they should give you some basic principles to use in communicating online. For Netiquette Core Rules visit The Core Rules of Netiquette web page.

Contacting the Instructor

The instructor for this course is Dr. Jeremy Lin (jlin137@jhu.edu). Feel free to contact me with comments, questions, and concerns.

You will receive a response within 24-48 hours.

All email messages will be sent to you via your JHU email account, so you should be in the habit of checking that account every day or you should ensure that your JHU email account forwards messages to another account of your choice.

Professionalism and respect is expected throughout this course, whether online, in person, emailing, or calling.

VII Course Protocols

How will I know about changes to the course?

Frequently, you will find new announcements posted in the Announcements, which contain information about current course activities that you are working on and any changes to the course. Please check announcements every time that you log into your online course.

How should I communicate with others in this course?

You should communicate often with your classmates and with Dr. Lin. The majority of communication will take place within the Discussion forums. When you have a question about an assignment or a question about the course, please email Dr. Lin, or post your question in the course’s “Ask Your professor” forum.
Are there any requirements for sending e-mail messages?

When you send an e-mail message to the instructor or to another participant in the course, please observe the following guidelines:

- Include the title of the course in the subject field (e.g., JHU Energy Tech).
- Keep messages concise, and check spelling and grammar.
- Send longer messages as attachments.
- Sign your full name (the sender’s email is not always obvious).

University Policies

General
This course adheres to all University policies described in the academic catalog. Please pay close attention to the following policies:

Students with Disabilities
Johns Hopkins University is committed to providing reasonable and appropriate accommodations to students with disabilities. Students with documented disabilities should contact the coordinator listed on the Disability Accommodations page. Further information and a link to the Student Request for Accommodation form can also be found on the Disability Accommodations page.

Ethics & Plagiarism

JHU Ethics Statement: The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition. Report any violations you witness to the instructor. Read and adhere to JHU’s Notice on Plagiarism.

Dropping the Course
You are responsible for understanding the university’s policies and procedures regarding withdrawing from courses found in the current catalog. You should be aware of the current deadlines according to the Academic Calendar.

Getting Help
You have a variety of methods to get help on Blackboard. Please consult the resource listed in the "Blackboard Help" link for important information. If you encounter technical difficulty in completing or submitting any online assessment, please immediately contact the designated help desk listed on the AAP online support page. Also, contact your instructor at the email address listed in the syllabus.
Copyright Policy
All course material are the property of JHU and are to be used for the student’s individual academic purpose only. Any dissemination, copying, reproducing, modification, displaying, or transmitting of any course material content for any other purpose is prohibited, will be considered misconduct under the JHU Copyright Compliance Policy, and may be cause for disciplinary action. In addition, encouraging academic dishonesty or cheating by distributing information about course materials or assignments which would give an unfair advantage to others may violate AAP’s Code of Conduct and the University’s Student Conduct Code. Specifically, recordings, course materials, and lecture notes may not be exchanged or distributed for commercial purposes, for compensation, or for any purpose other than use by students enrolled in the class. Other distributions of such materials by students may be deemed to violate the above University policies and be subject to disciplinary action.

Code of Conduct
To better support all students, the Johns Hopkins University non-academic Student Conduct Code has been integrated and updated to include all divisions of the University. In addition, it is important to note that all AAP students are still accountable for the Code of Conduct for Advanced Academic Programs.

Title IX
Confidentiality and Mandatory Reporting
As an instructor, one of my responsibilities is to help create a safe and inclusive learning environment on our campus. I also have mandatory reporting responsibilities related to my role as a Responsible Employee under the Sexual Misconduct Policy & Procedures (which prohibits sexual harassment, sexual assault, relationship violence and stalking), as well as the General Anti-Harassment Policy (which prohibits all types of protected status based discrimination and harassment). It is my goal that you feel able to share information related to your life experiences in classroom discussions, in your written work, and in our one-on-one meetings. I will seek to keep information you share private to the greatest extent possible. However, I am required to share information that I learn of regarding sexual misconduct, as well as protected status based harassment and discrimination, with the Office of Institutional Equity (OIE). For a list of individuals/offices who can speak with you confidentially, please see Appendix B of the JHU Sexual Misconduct Policies and Laws.

For more information on both policies mentioned above, please see: JHU Relevant Policies, Codes, Statements and Principles. Please also note that certain faculty and other University community members also have a duty as a designated Campus Safety Authority under the Clery Act to notify campus security of certain crimes, as well as a duty under State law and University policy to report suspected child abuse and/or neglect.