



Department of Electrical & Computer Engineering
ECE666: POWER SYSTEMS OPERATION
WINTER 2023

Instructor: Professor Kankar Bhattacharya (kankar@uwaterloo.ca)

Lectures: [REDACTED]

Room: [REDACTED]

Summary: The course deals with operation of the power system in a competitive electricity market environment. Basics of power system operation such as economic load dispatch, unit commitment, hydro-thermal coordination, optimal power flow and security constrained economic dispatch will be introduced. Operation of electricity markets, auction models and different pricing formations will be discussed. The course covers transmission system operations including transmission open access, transmission pricing paradigms and methods, use of power transfer distribution factors in transmission pricing. It includes the topics of congestion management and firm transmission rights. Finally the course covers the very important topic of ancillary services- their definitions, usage and management.

Objectives

- a) Provide in-depth understanding of power system operation in a competitive environment.
- b) Understand various issues arising from electricity market operations.
- c) Analyze various operational and control issues using new mathematical models.

Reference Texts

1. A. J. Wood, B. F. Wollenberg and G. Sheble, *Power Generation, Operation and Control*, IEEE Wiley, 3rd Edition, 2014
2. D. S. Kirschen, G. Strbac, *Fundamentals of Power System Economics*, John Wiley & Sons, 2004.
3. M. Shahidehpour, H. Yamin, Z. Li, *Market Operations in Electric Power Systems*, Wiley Interscience, 2002.
4. Lecture notes, presentation material and reading material will be provided, as appropriate.

Examination

- Final Exam: 50%
- Assignments: 20%
- Project: 30%
 - The Project will be carried out individually, on an assigned topic. A report has to be prepared, which shall include computer modeling & simulations, as well as a critical review of research literature.
 - The project will be assessed and examined at the end of the course, details of which shall be announced on LEARN.
 - AUDIT students will have to fulfill the Assignment and Project requirements.

Course Outline

| Module | No. of Lectures (each 3 hours) | Topic | Details |
|--------|-----------------------------------|---|--|
| 1 | 3 | Power System Economic Operation | <ul style="list-style-type: none"> Economic load dispatch, Multi-area interchanges and economics of integrated operation. Unit commitment and Hydro-thermal coordination. |
| 2 | 2 | Optimal Power Flow | <ul style="list-style-type: none"> Review of power flow analysis, fast decoupled power flow and dc power flow. SCED and SCUC. Optimal Power Flow and applications, SCOPF. |
| 3 | 2.5 | Electricity Market Operations | <ul style="list-style-type: none"> Supply and demand functions, market equilibrium. Uniform price and LMPs, price based unit commitment. Market power and its mitigation. Imperfect markets- Cournot competition. |
| 4 | 2.5 | Transmission Operations | <ul style="list-style-type: none"> Transmission open access. Transmission cost and transmission pricing, Distribution Factors in transmission pricing. Transmission capacity definitions, ATC calculation. Congestion management, FTRs and FTR auctions. |
| 5 | 2 | Ancillary Services and System Security | <ul style="list-style-type: none"> Ancillary services classifications and definitions. Frequency control services- primary regulation and AGC. Reliability indices, multi-area reliability. Demand Response, Reactive power as ancillary service. |

Covid-19 Guidelines

As per latest guidelines of the University, classes will be held in-person in the Winter 2023 term. However, plans will remain flexible in case public health conditions change and we need to scale back in-person teaching. We will follow University guidelines.

- If in-person classes are not allowed, we shall transfer to online lectures, which will be live streamed during the same scheduled hours, will be recorded and archived for the entire academic term.
- In case of cancellation of in-person final exam, a take-home final exam will be held for the same time duration. The marking scheme for the course, in such circumstances, will be as follows:
 - Final Exam: 40%
 - Assignments: 20%
 - Project: 40%
- For latest updates, please refer to:

<https://uwaterloo.ca/registrar-resources-staff-and-faculty/covid-guidelines-instructional-space#outline>

Policy on Academic Integrity

Academic Integrity: To maintain a culture of academic integrity, members of the University of Waterloo are expected to promote honesty, trust, fairness, respect and responsibility. A student is expected to know what constitutes academic integrity, to avoid committing academic offences, and to take responsibility for their actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from course instructor, academic advisor, or Graduate Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71- Student Discipline. For

information on categories of offenses and types of penalties, students should refer to Policy 71- Student Discipline, <https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-71>.

Grievance: A student who believes that a decision affecting some aspect of their University life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70: Student Petitions and Grievances, Section 4, <https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-70>.

Appeals: A student may appeal the finding and/or penalty in a decision made under Policy 70: Student Petitions and Grievances (other than regarding a petition) or Policy 71: Student Discipline if a ground for an appeal can be established. Read Policy 72: Student Appeals, <https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-72>.

Academic Integrity Office (UW): <https://uwaterloo.ca/academic-integrity/>.