UNIVERSITY OF WATERLOO

Department of Electrical & Computer Engineering
ECE666: POWER SYSTEMS OPERATION
WINTER 2021

Instructor: Professor Kankar Bhattacharya (kankar@uwaterloo.ca)
Lectures: [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 will also cover transmission system operations including transmission open access, transmission pricing paradigms and methods, use of power transfer distribution factors in transmission pricing. Transmission system operation also includes the topics of transmission 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
d) Discuss operational practices of various electricity markets around the world

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 and G. Strbac, *Fundamentals of Power System Economics*, John Wiley and Sons, 2004.
3. M. Shahidehpour, H. Yamin and 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% (oral component and a written component of equal weights)
- Assignments: 20%
- Project: 30%
    - To be carried out individually, on a topic assigned.

- A report has to be prepared, supported with computer modeling and simulations, if required.
- A seminar presentation may be required.
- The project will be examined at the end of the course- details to be announced on LEARN.

- AUDIT students need to fulfill the Assignment and Project requirements.

Course Outline

Module	No. of Lectures (each 3 hours)	Topic	Details
1	3	**Power System Economic Operation**	• Economic load dispatch, Multi-area interchanges and economics of integrated operation • Unit commitment and Hydro-thermal coordination
2	1	**Optimal Power Flow**	• Review of power flow analysis, decoupled power flow and dc power flow • Security Constrained Economic Dispatch • Optimal Power Flow and applications
3	2.5	**Electricity Market Operations**	• Supply and demand functions, market equilibrium • Types of electricity markets- uniform price and LMPs, price based unit commitment • Market power and its mitigation • Imperfect markets- Bertrand and Cournot competition, Nash equilibrium
4	3	**Transmission Open Access and Transmission Operations**	• Transmission open access, Transmission cost components, Transmission pricing paradigms and methods, Distribution Factors in transmission pricing • Transmission capacity definitions, ATC calculation • Transmission congestion management • FTRs and FTR auctions
5	2.5	**Ancillary Services and System Security**	• Ancillary services classifications and definitions • Frequency control services- primary regulation and AGC, NERC Control Performance Standards • Reliability indices, multi-area reliability, NERC Reliability Standards • Demand Response, Reactive power as an ancillary service

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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.

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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/.