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Instructor: Prof. Yury Dvorkin (dvorkin@nyu.edu)

Office hours: TBA, or by email

Course audience: This is an introductory class for graduate and senior-level undergraduate students that will not require prior power engineering courses. The course will start with a review of engineering concepts that will be necessary to successfully complete all course requirements. Students outside of ECE and NYU Tandon are encouraged to register, even in absence of power engineering background or prerequisites. Please email me if you have any questions or concerns.

Course description: This course will teach **multi-disciplinary** fundamentals of engineering, optimization, that constitute modern power system economics and planning. These fundamentals will enable understanding and studying the concept of **smart grids** as a particular case of large-scale, network-constrained, cyber-physical infrastructure. The class will review basics of power system analysis (AC and DC power flows) and economic theory (microeconomics). The class will teach optimization methods that are used in the modern power system planning tools – optimal power flow and unit commitment. These tools will be discussed in the context of deregulated **electricity markets** with **renewable**, **demand response** (smart appliances, electric vehicles) and **energy storage** resources. We will use mathematical modeling to characterize unique features of these resources (stochasticity, limited controllability, etc), in order to integrate them with the aforementioned planning tools and to analyze their impact on electricity markets. Finally, we will study methods to optimize investments in power system assets (**generators**, **transmission lines**, **energy storage**) to ensure long-term **sustainability** of the power system sector. The final part of this class will discuss **current research problems** in the area of power system economics, operations and planning, as well as **cybersecurity**, and will host students' project presentations.

Tentative lecture schedule:

- Lecture 1: Course Introduction & Review of Power Engineering
- Lecture 2: Smart Grids: Design and Control Principles
- Lecture 3: Introduction to Linear Programming & Economic Dispatch Problem
- Lecture 4: Introduction to Mixed-Integer Linear Programming & Unit Commitment Problem
- Lecture 5: Network-Constrained Optimization & Optimal Power Flow Problem
- Lecture 6: Convex Relaxations of Optimal Power Flow
- Lecture 7: Uncertainty-Aware Methods for Optimal Power Flow

- Lecture 8: Smart Grid Technologies in Electricity Markets: Modeling Renewables, Demand Response, and Energy Storage in Economic Dispatch, Optimal Power Flow, and Unit Commitment
- Lecture 9: Security in Smart Grids: How Smart Grid Technologies Redefine “Security” and How Much it Costs? Cybersecurity in Smart Grids.
- Lecture 10: Uncertainty Management in Smart Grids
- Lecture 11: Investments in Smart Grids: Long-term Planning and Coupling with Other Cyber Physical Systems
- Lecture 12: Policy and Regulation for Smart Grids

Books/Reading

[Main; HW] D. Kirschen & G. Strbac, *Fundamentals of Power System Economics*, Wiley, 2004

[Main] State-of-the-art papers in IEEE Transactions on Power Systems

[Extra] Steven Stoft, *Power System Economics: Designing Markets for Electricity*, Wiley, 2002

[Extra] A. Conejo, *Decision Making Under Uncertainty in Electricity Markets*, Springer, 2010.

Grades:

- Homework (five biweekly assignments) – 50%
- Take-home exam (related to homework problems; 1-page cheat sheet is allowed)– 15%
- Group/individual project (List of topics is available in Lecture #1) – 20%
- Three online quizzes – 15%

Dissemination of materials:

- All class materials are posted on NYU Classes: <https://newclasses.nyu.edu/portal/site/88c2a6c5-46fe-47d5-b731-ecbe1657289e/page/a9e2157b-0508-439b-af7a-66bf43d48c78>
- Homework is posted biweekly after the lecture
- Slack channel can be joined here: https://join.slack.com/t/officehourssmartgrids/shared_invite/zt-gz98oadg-eb2TXfrhXp6rdahJnnMxFA).

Important Resources:

- NYU Tandon Policy on Academic Integrity: <http://engineering.nyu.edu/online-asynchronous-orientation/academic-integrity.php>
- If you require reasonable accommodation due to documented disability, please email me and check the following NYU resource: <http://www.nyu.edu/students/communities-and-groups/students-with-disabilities.html>