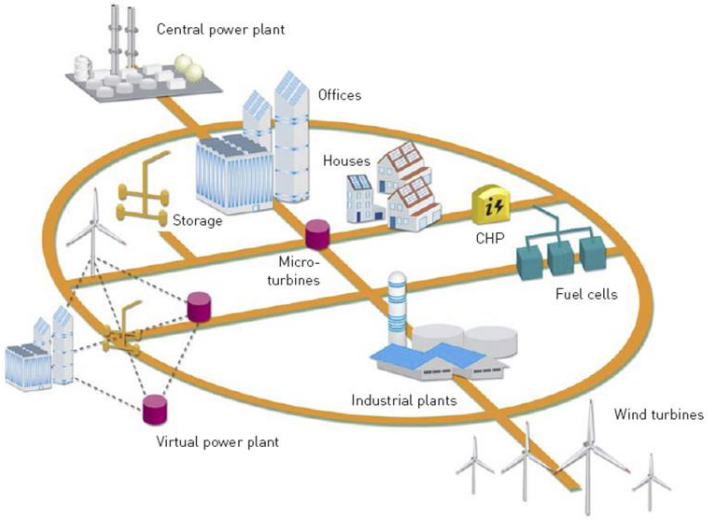
EL-GY 6623 Smart Grids: Control, Economics, Planning and Regulation

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 power engineering, economics, optimization, and policy analysis 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 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 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 summarize **current research problems** in the area of power system economics and planning 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-Ingeter Linear Programming & Unit Commitment Problem
Lecture 5:	Network-Constrained Optimizaion & Optimal Power Flow Problem
Lecture 6:	Electricity Markets: Organization, Services, Participants, Competition. How to Model Electricity Markets?

Lecture 7:	Smart Grid Technologies in Electricity Markets: Modeling Renewables, Demand Response, and Energy Sotrage in Economid Dispatch, Optimal Power Flow, and Unit Commitment
Lecture 8:	Security in Smart Grids: How Smart Grid Technologies Redfine "Security" and How Much it Costs?
Lecture 9:	Uncertainty Management in Smart Grids
Lecture 10:	Investments in Smart Grids: Long-term Planning and Coupling with Other Cyber Physical Systems
Lecture 11:	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 (biweekly assignments) – 30%
- Midterm (related to homework problems; 1-page cheat sheet is allowed,)– 20%
- Group/individual project (List of topics available below) – 30%
- Class attendance ***and*** participation – 20%

Dissemination of materials:

- All class materials are posted on NYU Classes
- Homework is posted biweekly after the lecture

Project:

The following topics are available/suggested:

- **[Preferred]** Suggest your topic for the project, but first schedule a meeting with me to discuss the matter
- Impact of AC and DC Transmission Constraints on Unit Commitment Decisions
- Modeling Energy Storage in Smart Grids using Chance Constrained Optimization
- Modeling Demand Response in Smart Grids using Chance Constrained Optimization
- Population Games in Electricity Markets
- Modeling Non-Perfect Competition in Electricity Markets
- Co-optimization of Energy and Ancillary Service Markets
- Multi-stage Planning with Uncertainty Using Linear Decision Rules
- Multi-stage Planning with Uncertainty Using Non-Linear Decision Rules
- Participation of Energy Storage and Demand Response in Capacity Markets
- […]

Please note that it is up to you whether you intend to collaborate on the project with fellow students or work independently. The groups should itemize each member's specific contributions.

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