# Electricity Markets

**5th module, Spring 2019**

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## Course information

**Course Website:** at my.nes
**Instructor's Office Hours:** by appointment
**Class Time:** see plan at my.nes
**Room Number:**
**TAs:**

## Course description

Electricity is a basic necessity of daily life and a vital input to industry in any society around the world. Electricity also plays an important role in the climate policies that are aimed at the global warming problem, as it is possible to decarbonize electricity production (with renewables or nuclear generation) and then electrify the energy system (including heating and transportation). Electricity and the economics of electricity have therefore been increasing in importance even further.

Electricity, however, is a peculiar good. Electricity is not storable in large quantities and transportation is often complicated as the paths taken by electrical flows are determined by natural laws. Moreover, the cost of production of electricity mostly depends on temporal dimensions (such as how long in advance electricity is ordered and for what duration). These peculiarities affect competitive outcomes and the economics of market designs for electricity markets.

The course of Electricity Markets introduces the main elements of the electricity industry, generation, distribution and transmission, the main types of markets in which they are traded and the economic logic by which these markets are governed. The impact of climate policy, especially in the form of the deployment of (intermittent) renewable power sources on the functioning of these markets is discussed (especially increasing retail prices coupled with decreasing wholesale prices and decreasing network stability).

The course aims at giving the student knowledge about various topics related to electricity markets, such as the pricing of electricity and transmission capacity and the interactions with other energy markets, such as gas markets. Students will also gain knowledge to appraise the effects (the challenges and opportunities) climate policy will have (and- for some countries – has already) on the electricity industry: The radical German energy policy as a "natural energy experiment" already provides fascinating insights.

The course offers theory, empirical evidence and interactive computer simulations for electricity power station investment for long-term and short-term scenarios. Students are expected to have background knowledge in economics, be familiar with algebra as well as understand microeconomics.

By completing this course a successful student will be able to

- Analyze and discuss the economic fundamentals driving the profitability of (and the investment in) electricity generation (power station) and the main forms of market intervention (capacity payment mechanisms);
- Understand the basic peculiarities of electricity and electricity power stations and transmission that shape the market design in the electricity industry.
- Understand the key issues in functioning of electricity markets, and their influence on the market outcomes for consumers and producers;
- Gain insights into the climate policy issues and assess advantages and disadvantages of currently used and future proposed climate policies for the electricity industry and the electricity consumers;
- Discuss research trends within the field of electricity economics with a group of peers.

The approaches learned in the course would also enable the student to examine economic problems in other related fields such as the theory of industrial organization, political economics, and environmental economics.

## Course requirements, grading, and attendance policies

**Prerequisites:** Micro 1-2, Math 1-2, Statistics, Basic programming in Python
**Teaching and Work Forms:** 2 lectures per week and (in total) 3 exercise classes. During exercise classes students will be mostly doing exercises, discussing case studies and/or presenting articles.
**Grading policy:** Participants are expected to prepare the readings for the class, and to actively and constructively participate in class discussions. Final grade for the course will be based on the final exam (60% of the grade), home works (25%), quizzes during the class (15%). There will be 3 home works in total.
**Attendance policy:** Attendance is not compulsory. However, it will be marked both at the lectures and at the exercise classes and those with attendance below 50% will not be allowed to re-take the final exam. Also, absence during the class forfeits the grade points that can be earned with the quiz during that class.

## Course contents

### Readings

**All literature is available in the library or will be provided.**
*(The literature in italics is* <u>*not obligatory*</u>*, but given as reference literature)*
**A. Transmission markets**

| | |
|---|---|
| Biggar | Biggar, D.R., Hesamzadeh, M.R. 2014. The Economics of Electricity Markets. |
| Shively-E | Shively, B., Ferrare, J. Understanding today’s electricity business. Enerdynamics Corp. |

| | |
|---|---|
| Stoft | Stoft, S. 2002. Power system economics: designing markets for electricity. IEEE Press: Wiley. |
| VanKoten | Cookbook DC-flow calculations |
| *Green* | *Green, R.2007. Nodal pricing of electricity: how much does it cost to get it wrong?The Journal of Regulatory Economics 31, p.125-149* |
| *Grimm* | *Grimm,V. Martin, A., Weibelzahl, M, Zoettl,G. 2014. Transmission and generation investment in electricity markets: the effects of market splitting and network fee regimes. Discussion Paper No. 460. FAU Erlangen–Nuremberg* |
| *Joskow 2000* | *Joskow P, Tirole J, Transmission rights and market power on electric power networks, RAND Journal of Economics, 31(3), 2000, 450–487.* |
| *Joskow 2005* | *Joskow, P., Tirole, J. 2005. Merchant Transmission Investment, Journal of Industrial Economics, 53(2), pages 233-264, 06.* |
| *Leuthold* | *Leuthold, F., Weigt, H., von Hirschhausen, C. 2008. Efficient pricing for European electricity networks - The theory of nodal pricing applied to feeding-in wind in Germany, Utilities Policy 16(4), p. 284-291.* |
| *McCalley* | *McCalley, J.D. Lecture Notes " DCPowerFlowEquations". Iowa State University* |
| *MIT* | *The future of the electric grid. (p.243-245)* |
| *NVE* | *NVE, 2010. The introduction to a Day-Ahead market - market design, monitoring and surveillance.* |
| *Oren 1995* | *Oren, S.S., Spiller, P.T., Varaiya, P., Wu, F. 1995. Nodal prices and transmission rights: A critical appraisal. The Electricity Journal, 8(3), p. 24-35.* |
| *Oren 1998* | *Oren, S. S. 1998. Transmission pricing and congestion management: efficiency, simplicity and open access. In Proceedings of the EPRI Conference on Innovative Pricing, Washington DC, 19.* |
| *Reader* | *Reader with a selection of articles (news articles and research reports) on renewables, cap-and-trade, UNCOP & climate change negotiations, and energy density considerations.* |
| *Rosenthal 2015* | *Rosenthal, R.E. 2015. GAMS, A User's Guide.* pages.cs.wisc.edu/~swright/635/docs/GAMSUsersGuide.pdf |
| *Schweppe 1988* | *Schweppe, F. C., Tabors, R. D., Caraminis, M. C., & Bohn, R. E. (1988). Spot pricing of electricity.* |

**B. Generation markets**

| | |
|---|---|
| ACER 2013 | ACER. 2013. Capacity remuneration mechanisms and the internal market for electricity. |
| Borenstein | Borenstein, S., & Holland, S. (2005). On the Efficiency of Competitive Electricity Markets with Time-Invariant Retail Prices. RAND Journal of Economics, 469-493. |
| Biggar | Biggar, D.R., Hesamzadeh, M.R. 2014. The Economics of Electricity Markets. |
| Edwards | Edwards, D. 2010. Energy trading & investing: trading, risk management, and structuring deals in the energy Markets. New York: McGraw-Hill. |
| EU-EC | European Commission. (2015) Consultation on a new Energy Market Design. Available on http://ec.europa.eu/energy/en/consultations/public-consultation-new-energy-market-design |
| Green 2015 | Green, R., Leautier, T. 2015. Do costs fall faster than revenues? Dynamics of renewables entry into electricity markets. Working paper TSE-591. |
| Helm | Helm, D. 2005. The assessment: the new energy paradigm. Oxford review of economic policy, vol. 21, no. 1 |
| Hirth 2015 | Hirth, L. 2015. The optimal share of variable renewables. How the variability of wind and solar power affects their welfare-optimizing deployment. The Energy Journal (FEEM Working Paper 90.2013). |
| Hirth 2016 | Hirth, L., Ueckerdt, F., & Edenhofer, O. 2016. Why wind is not coal: on the economics of electricity generation. The Energy Journal, 37(3), 1-27. |
| Shively-E | Shively, B., Ferrare, J. Understanding today's electricity business. Enerdynamics Corp. |
| Stoft | Stoft, S. 2002. Power system economics: designing markets for electricity. IEEE Press: Wiley. |
| *Hogan 2005* | *Hogan, W.W. 2005. On an "energy only" electricity market design for resource adequacy. Mimeo.* |
| *Joskow 2007* | *Joskow, P., Tirole, J. 2007. Reliability and competitive electricity markets. RAND Journal of Economics 38(1), pp. 60–84.* |
| *Joskow 2008* | *Joskow, P.L. 2008. Capacity payments in imperfect electricity markets: Need and design. Utilities Policy.* |

**C. Market issues**

BL — Bessembinder, H., & Lemmon, M. L. (2002). Equilibrium pricing and optimal hedging in electricity forward markets. the Journal of Finance, 57(3), 1347-1382.

Biggar — Biggar, D.R., Hesamzadeh, M.R. 2014. The Economics of Electricity Markets.

Joskow 2007 — Joskow, P., Tirole, J. 2007. Reliability and competitive electricity markets. RAND Journal of Economics 38(1), pp. 60–84.

Viehmann — Viehmann, J. (2017). State of the German Short-Term Power MarketAktueller Stand des deutschen Kurzfrist-Strommarktes. Zeitschrift für Energiewirtschaft, 41(2), 87-103.

VanKoten — Van Koten, S. 2019. Forward premia in electricity markets. An experiment. Unpublished manuscript.

## Detailed schedule

| Week | | |
|---|---|---|
| | **A. Transmission markets** | |
| 1 | The system 1) | - Shively-E Ch.1, 2, 4, 5, 6, 7.<br>- Biggar Ch. 2 |
| | The system 2) | - Shively-E Ch.1, 2, 4, 5, 6, 7.<br>- Biggar Ch. 2 |
| 2 | Nodal pricing 1): counterintuitive flows and prices. | - Stoft 390-399<br>- Kirschen Ch.6 |
| | Nodal pricing 2): general (formal) methods and computational tools (GAMS). | - Van Koten-Cookbook DC-flow calculations<br>- Biggar Ch. 6<br>- Biggar, p.153-155<br>- *McCalley*<br>- *Rosenthal 2015* |
| | **B. Generation markets** | |
| | Generation Introduction (Fundamentals)<br>*(exercise session on nodal pricing)* | - Shively-E Ch. 4.<br>- Edwards p.93-112 +117 (California) |
| 3 | Generation-only trading simulation LT & ST<br>*(DOUBLE LECTURE IN THE COMPUTER LAB)* | - Helm |
| | Generation-only trading simulation LT & ST<br>*(DOUBLE LECTURE IN THE COMPUTER LAB)* | - BL<br>- Van Koten 2019 |
| 4 | Optimal investment: optimal shortage, screen curves, load duration curve. Missing money & capacity payments and subsidies | - Stoft p.33-45, 123-129<br>- Biggar, p.134-135<br>- Biggar Ch. 9.2, Ch. 9.3. 10.1<br>- ACER 2013 |
| | Optimal investment: applications. Effects and costs of intermittent (renewable) generation<br>*(exercise session on load-duration and screening analysis)* | - Hirth 2015<br>- Hirth 2016 |
| 5 | Optimal investment: applications. Effects and costs of intermittent (renewable) generation | - Green 2015 |
| | **C. Market issues** | |
| 6 | Optimal investment: general (formal) methods.<br>*(exercise session on load duration and screening analysis and intermittent generation)* | - Biggar,, p.153-155<br>Ch. 9.1. |