PhD Course: Electricity Price Forecasting

17-18 August 2026

Lecturer: Professor Rafał Weron, Wrocław University of Science and Technology.

Time: Monday 17 August, 13:00-16:00, Tuesday 18 August, 9:00-12:00

Location: Department of Economics and Business Economics, Aarhus University. Building 1814, Room 151.

Organizer: Professor Niels Haldrup, Center for Research in Energy: Economics and Markets (CoRE).

Course description

Electricity price forecasting is a rapidly developing research area at the intersection of econometrics, statistics, machine learning, finance and engineering. The course introduces PhD students to the central modelling ideas, empirical challenges and evaluation principles that arise when forecasting prices in modern wholesale electricity markets. Emphasis is placed on day-ahead markets, but the course also connects day-ahead forecasting to intraday, mid-term and longer-horizon forecasting problems.

The course begins with the distinctive features of electricity prices: non-storability of electricity at scale, the need for continuous system balance, strong calendar and weather dependence, price spikes, negative prices, changing renewable penetration, cross-border market coupling and the increasing role of short-term flexibility. These features explain why electricity price forecasting has developed a methodology and benchmarking culture that differs from many standard financial or macroeconomic forecasting applications.

The methodological core of the course covers benchmark and state-of-the-art approaches for point, probabilistic and distributional forecasting. Topics include naive and autoregressive models, ARX/LEAR-type models, preprocessing and transformations, calibration-window choice, forecast averaging and combinations, machine-learning and deep-learning approaches, NBEATSx, distributional neural networks, quantile regression averaging, conformal prediction, isotonic distributional regression and postprocessing of point forecasts.

A final part of the course focuses on rigorous forecast evaluation. Students will discuss best practices for benchmark design, rolling-window evaluation, error metrics, statistical tests, coverage and sharpness, CRPS and pinball scores, and the limits of RMSE/MAE as sufficient performance criteria. The course also highlights economic evaluation, including how loss functions relate to trading profits and risk in day-ahead markets.

Topics to be covered:

Electricity forecasting I

Intro: Energy forecasting literature, Power markets across the globe, Model taxonomy

'Toy' models: The forecasting setup, Naive models, (Auto)regressive models, Shallow neural networks, Exponential smoothing models, Supply stack models

Beyond point forecasts: Probabilistic forecasts, Reliability & sharpness, Postprocessing point forecasts, Historical simulation, Conformal prediction

Forecast accuracy: Absolute and square errors, Percentage errors, Scaled and relative errors, Testing for coverage, CRPS and the pinball score, DM-type tests

Tips and tricks: Transformations, Seasonal decomposition, Combining forecasts, Averaging across calibration windows, Calibration window selection

Electricity price forecasting II

Lasso, DNN and beyond: Stepwise regression, Shrinkage (regularization), LASSO-Estimated AR (LEAR), Deeper and deeper, Interpretable AI, Foundation models

Temporal reconciliation: Predicting block prices, Predicting price spreads, Minimum trace reconciliation, Information combination

Probabilistic forecasts revisited: Quantile Regression Averaging, Isotonic Distributional Regression, Combining probabilistic forecasts, GAMLSS, Distributional Deep Neural Nets, Probabilistic inputs

Financial evaluation: Day-ahead bidding with BESS, Beyond RMSE and MAE, Which loss function to minimize?

Course objectives

Upon completion of the course, students will have:

Knowledge of

- the institutional and empirical features that make electricity price forecasting different from standard financial and macroeconomic forecasting;
- core econometric, statistical-learning and machine-learning approaches used in day-ahead and intraday electricity price forecasting;
- the distinction between point, interval, probabilistic, distributional and path/ensemble forecasts;
- standard benchmark designs, preprocessing choices, calibration-window strategies and forecast-combination methods;
- modern forecast-evaluation principles, including statistical accuracy, reliability, sharpness, and economic/trading-oriented evaluation.

Skills to

- formulate an electricity price forecasting problem with appropriate horizons, target variables, regressors and evaluation windows;
- implement or critically assess benchmark models such as naive, ARX and LEAR-type models;
- compare econometric models with selected machine-learning and deep-learning approaches in a reproducible empirical design;
- evaluate point and probabilistic forecasts using appropriate loss functions, scores and statistical tests;
- interpret the economic implications of forecasting errors for bidding, trading, storage or risk-management applications.

Competences

- choose a modelling approach that is appropriate for a given electricity-market forecasting problem;
- critically discuss the strengths and limitations of econometric, machine-learning and deep-learning methods in electricity price forecasting;
- assess whether forecast improvements are statistically robust and economically meaningful;
- identify promising directions for further PhD-level research in energy forecasting and electricity market modelling.

Course format

The course/lecture series is intended for PhD students, postdoctoral researchers, and faculty interested in electricity markets and electricity market modelling and forecasting. The lectures are covered over two days. On day 2, there will also be a presentation in the afternoon by Rafał Weron on recent ongoing work.

In order to obtain ECTS credits for the course, PhD students are required to write an essay of 10 pages focusing on electricity price forecasting. The exact topic of the essay must be agreed in advance with the lecturer and the course coordinator following a 45-minute discussion. The essay can include methodological, theoretical, and/or empirical elements from the student's own research field, provided that these have potential relevance for application to the course topic.

The final essay must be submitted no later than **1 October 2026** and will be assessed as part of the approval of the course activity following a 30-minute presentation and discussion.

For PhD students at AU ECON, the course has been pre-approved as an internal BSS PhD course equivalent to **2 ECTS credits**.

Preliminary programme

Monday 17 August 2027

12:00-12:45 Lunch
13:00-14:15 Lectures, Electricity Price Forecasting I
14:15-14:45 Break
14:45-16:00 Lectures, Electricity Price Forecasting I

Tuesday 18 August 2027

9:00-10:15 Lectures, Electricity Price Forecasting I
10:15-10:45 Break
10:45-12:00 Lectures, Electricity Price Forecasting I
12:00-13:00 Lunch

14:00-15:00 Lecture TBD

Readings

Reviews:

P. Ghelasi, F. Ziel (2025) *From day-ahead to mid and long-term horizons with econometric electricity price forecasting models*, Renewable and Sustainable Energy Reviews 217, 115684 (doi: 10.1016/j.rser.2025.115684). Working paper version available from arXiv: https://arxiv.org/abs/2406.00326

J. Lago, G. Marcjasz, B. De Schutter, R. Weron (2021) *Forecasting day-ahead electricity prices: A review of state-of-the-art algorithms, best practices and an open-access benchmark*, Applied Energy 293, 116983 (doi: 10.1016/j.apenergy.2021.116983). Working paper version available from arXiv: https://arxiv.org/abs/2008.08004. Python codes available from *GitHub*

J. Nowotarski, R. Weron (2018) *Recent advances in electricity price forecasting: A review of probabilistic forecasting*, Renewable and Sustainable Energy Reviews 81(1), 1548-1568 (doi: 10.1016/j.rser.2017.05.234). Earlier working paper version available from RePEc: https://ideas.repec.org/p/wuu/wpaper/hsc1607.html

R. Weron (2014) *Electricity price forecasting: A review of the state-of-the-art with a look into the future*, International Journal of Forecasting 30(4), 1030-1081 (Invited Paper; doi: 10.1016/j.ijforecast.2014.08.008)

Original articles:

A. Lipiecki, K. Bilińska, N. Kourentzes, R. Weron (2026) *Stealing accuracy: Predicting day-ahead electricity prices with Temporal Hierarchy Forecasting (THieF)*, International Journal of

Forecasting (doi: 10.1016/j.ijforecast.2026.03.003). Working paper version available from arXiv: https://arxiv.org/abs/2508.11372

K. Maciejowska, A. Lipiecki, B. Uniejewski (2026) *Statistical and economic evaluation of forecasts in electricity markets: Beyond RMSE and MAE*, Energy Conversion and Management 356, 121408 (doi: 10.1016/j.enconman.2026.121408). Working paper version available from arXiv: https://arxiv.org/abs/2511.13616

T. Serafin, R. Weron (2025) *Loss functions in regression models: Impact on profits and risk in day-ahead electricity trading*, Energy Economics 148, 108596 (doi: 10.1016/j.eneco.2025.108596).

A. Lipiecki, B. Uniejewski, R. Weron (2024) *Postprocessing of point predictions for probabilistic forecasting of day-ahead electricity prices: The benefits of using isotonic distributional regression*, Energy Economics 139, 107934 (doi: 10.1016/j.eneco.2024.107934). Earlier working paper version available from arXiv: https://arxiv.org/abs/2404.02270. Julia codes available from *GitHub*

G. Marcjasz, M. Narajewski, R. Weron, F. Ziel (2023) *Distributional neural networks for electricity price forecasting*, Energy Economics 125, 106843 (doi: 10.1016/j.eneco.2023.106843).Working paper version available from arXiv: https://arxiv.org/abs/2207.02832. Python codes available from *GitHub*

K. Olivares, C. Challu, G. Marcjasz, R. Weron, A. Dubrawski (2023) *Neural basis expansion analysis with exogenous variables: Forecasting electricity prices with NBEATSx*, International Journal of Forecasting 39(2), 884-900 (doi: 10.1016/j.ijforecast.2022.03.001). Working paper version available from arXiv: https://arxiv.org/abs/2104.05522. Python codes available from *GitHub*

C. Kath, F. Ziel (2021) *Conformal prediction interval estimation and applications to day-ahead and intraday power markets*, International Journal of Forecasting 37(2), 777-799 (doi: 10.1016/j.ijforecast.2020.09.006)

K. Maciejowska, W. Nitka T. Weron (2021) *Enhancing load, wind and solar generation for day-ahead forecasting of electricity prices*, Energy Economics 99, 105273 (doi: 10.1016/j.eneco.2021.105273)

B. Uniejewski, R. Weron (2021) *Regularized quantile regression averaging for probabilistic electricity price forecasting*, Energy Economics 95, 105121 (doi: 10.1016/j.eneco.2021.105121). Working paper version available from RePEc: https://ideas.repec.org/p/wuu/wpaper/hsc1904.html

M. Narajewski, F. Ziel (2020) *Econometric modelling and forecasting of intraday electricity prices*, Journal of Commodity Markets 19, 100107 (doi: 10.1016/j.jcomm.2019.100107). Working paper version available from arXiv: https://arxiv.org/abs/1812.09081

K. Hubicka, G. Marcjasz, R. Weron (2019) *A note on averaging day-ahead electricity price forecasts across calibration windows*, IEEE Transactions on Sustainable Energy 10(1), 321-323

(doi: 10.1109/TSTE.2018.2869557). Earlier working paper version available from RePEc: https://ideas.repec.org/p/wuu/wpaper/hsc1803.html