Data-driven Strategies for Trading Renewable Energy Production

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OASYS
Optimization and Analytics for Sustainable energY Systems

European Research Council
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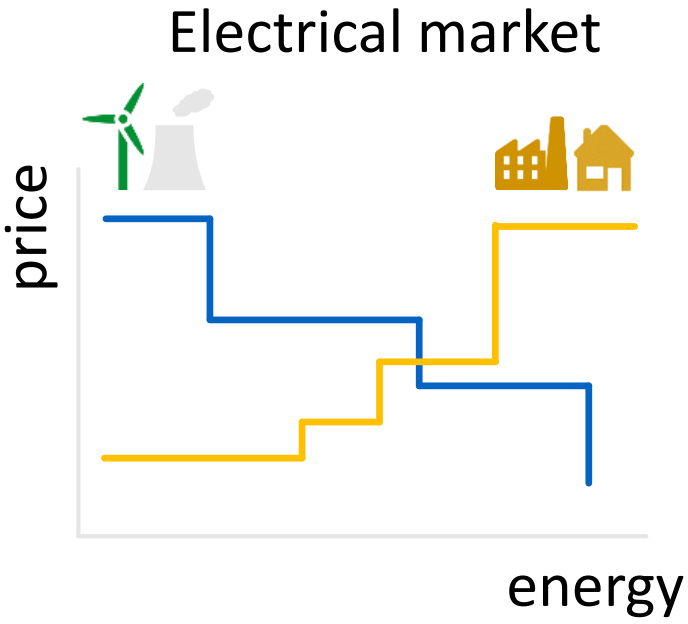
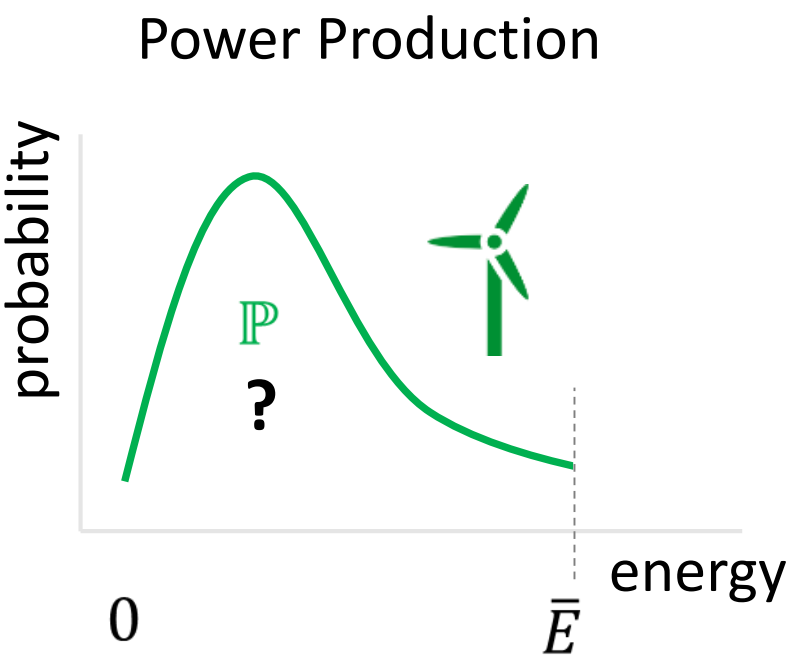
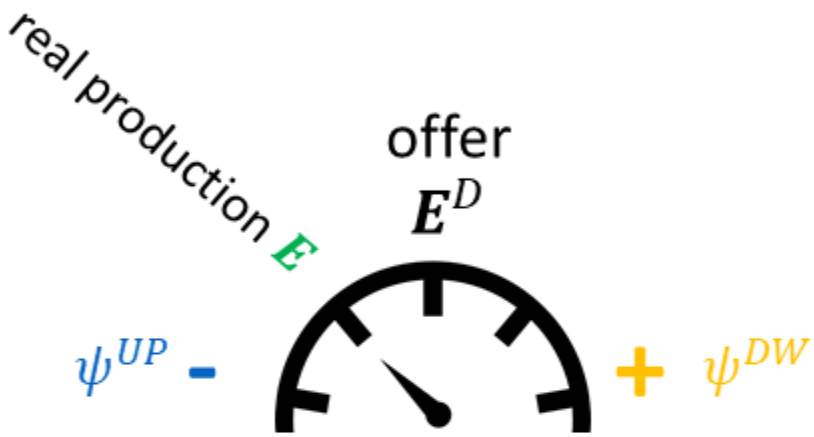
Introduction | Renewable energy in power systems





How much energy should the producer offer in the market to maximize profits?

Introduction | Opportunity cost



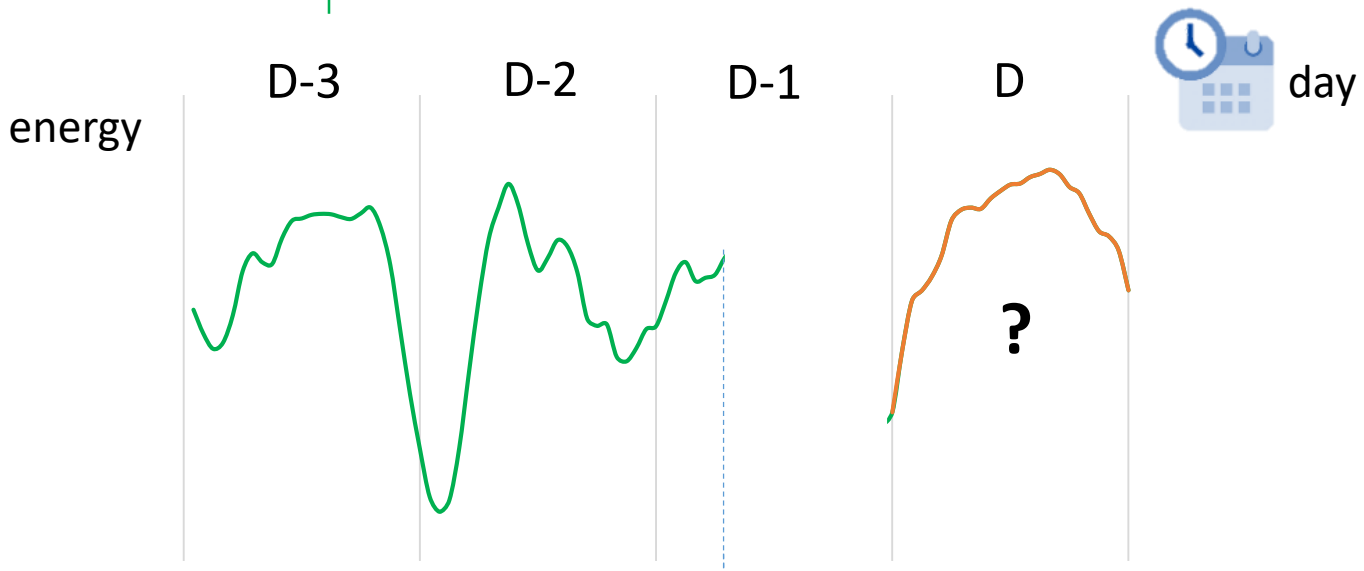
Dual Pricing System

$$\psi^{UP} \neq \psi^{DW}$$

$$Cost := \psi^{UP}(E^D - E)^+ + \psi^{DW}(E - E^D)^+$$

Newsvedor model !

Introduction | Renewable trader context



T_0 (the offer is done)

Known ***a priori*** at T_0

- Energy production (E)
- Opportunity Costs (ψ)
- Features

Relevant Features

- Forecasts
- Categorical variables

Models | Novel approaches to improve SAA

SAA method:

$$\mathrm{NV}_{SAA} := \min_{E^D} \frac{1}{N}\sum_{i=1}^{N} \psi^{UP}(E^D - E_i)^+ + \psi^{DW}(E_i - E^D)^+$$

$$\mathrm{NV}_{SAA} = \min \mathbb{E}(Cost)$$

Novel approaches to improve SAA with features:

a) Linear decision rule:

$$\mathrm{NV}_{Big\_NV} = \min_{E^D} \frac{1}{N}\sum_{i=1}^{N} \psi^{UP}(E^D(x) - E_i)^+ + \psi^{DW}\left(E_i - E^D(x)\right)^+$$

b) Machine Learning + Optimization techniques:

$$\mathrm{NV}_{ML+OPT} = \min_{E^D} \frac{1}{N}\sum_{i=1}^{N} w_{x,i}\left[\psi^{UP}(E^D - E_i)^+ + \psi^{DW}(E - E^D)^+\right]$$

a) G. Ban and C. Rudin, "The Big Data Newsvendor: Practical Insights from Machine Learning", 2015. Forthcoming in Operations Research.

b) D. Bertsimas and N. Kallus, "From Predictive to Prescriptive Analytics", 2014.

Case Study | Introduction

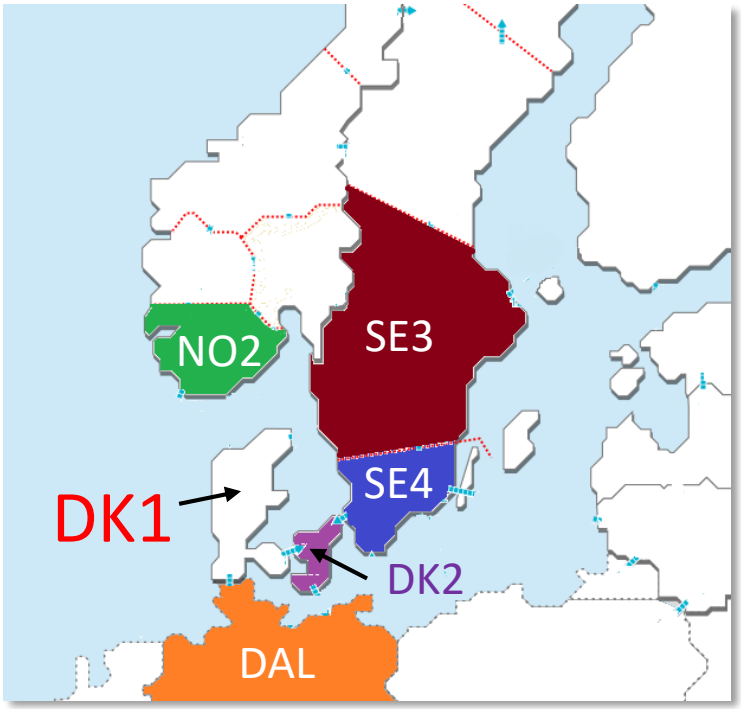
Bidding zone thought as aggregation of (on-shore) wind farms privately owned

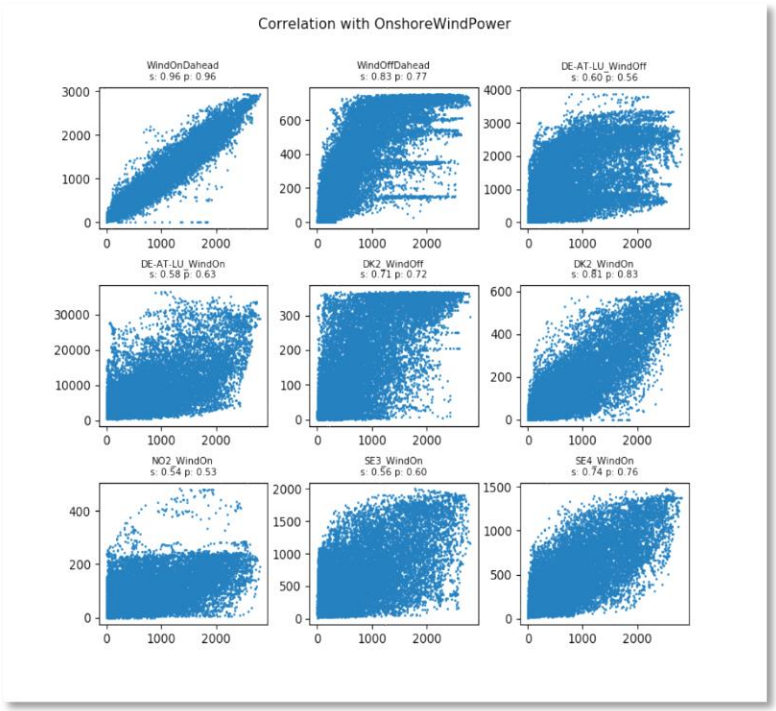
Bidding zones in Europe

entsoe

European Network of Transmission System Operators for Electricity

Case Study | Spatial correlation



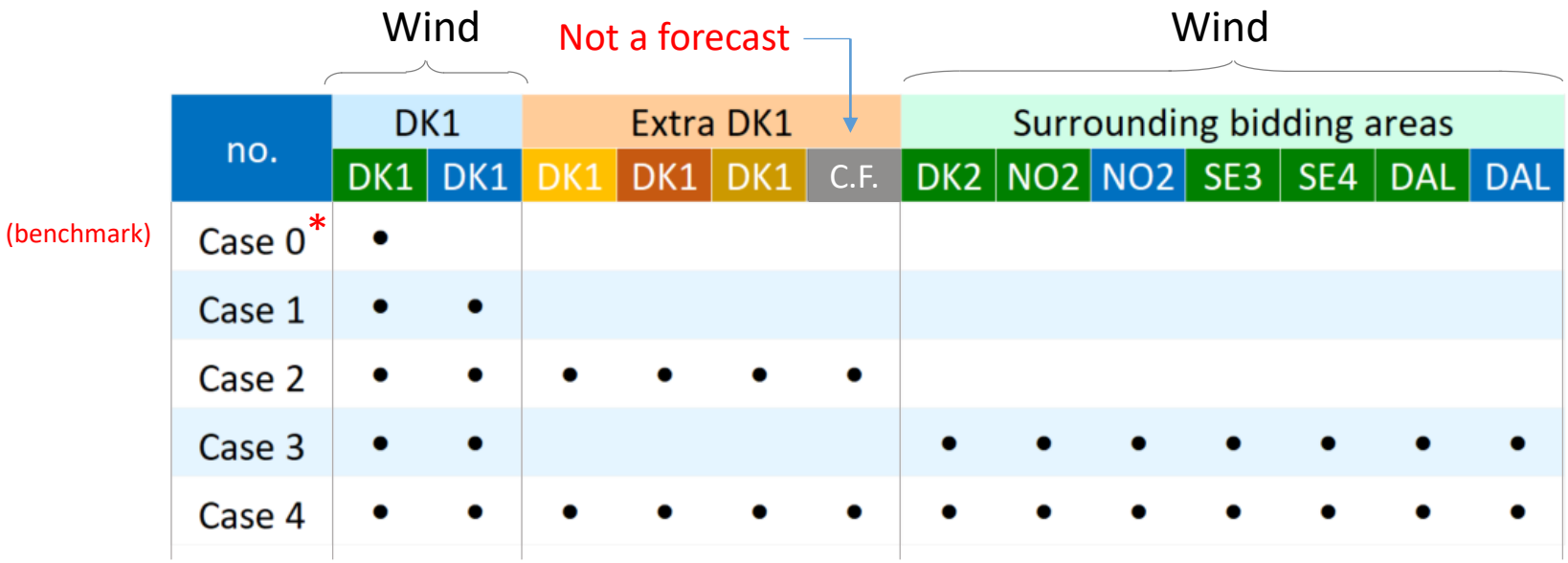


$$plot_i(DK1, X_i)$$

Spatial Correlation

Case Study | Data

* Case 0 is not feed into the algorithms



forecasts

- wind p.p. on-shore day-ahead
- wind p.p. off-shore day-ahead
- Solar p.p. day-ahead
- Generation forecast
- Total Load forecast
- Categorical features

p.p. : power production

- Categorical features
  - Month of the year
  - Day of the month
  - Day of the week
  - Hour of the day

	Day of the week						
	x_{d1}	x_{d2}	x_{d3}	x_{d4}	x_{d5}	x_{d6}	x_{d7}
Monday	1	0	0	0	0	0	0
Tuesday	0	1	0	0	0	0	0

Results | Main results

Case 0 offering a good prediction

Average cost of benchmark methods (no features):

SAA: 1738.80 Case 0: 542.91 (€/h)

Average improvement with respect to Case 0:

	C1	C2	C3	C4
a) Big_NV	-1.22%	-1.16%	3.37%	4.58%
b) ML+OPT	-0.16%	1.35%	2.81%	4.78%

Spatial features

Spatial features helps!

THANK YOU

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