Benefits of Probabilistic Forecasting in Power Trading

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Day-ahead price vs. imbalance price

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Benefits of Probabilistic Forecasting in Power Trading
Price uncertainty in power markets

Volatility evolution

![Volatility graph showing the comparison between spot and t+n maturity for Gas/Power and Stock options/agricultural commodities.]
Developments in short-term energy markets

Intraday power market trends

**Main findings (3/3)**

- Larger imbalance volumes and higher balancing capacity price.

**Intraday prices**

- In 2018: larger differences between DA and ID prices.

**Intraday trading volumes**

- Renewables growth and XBID go-live contributed to the further increase of intraday market volumes.

**Net imbalance volumes NL**

- Trend of larger imbalance volumes continues.

The short-term power market in the Netherlands reached a combined 38.7 TWh (2018: 39.5), with a 55.7% growth rate on the intraday market which reached 3.3 TWh (2018: 2.1 TWh).

**Intraday power market trends**

<table>
<thead>
<tr>
<th>Year</th>
<th>Trade volume [MWh/day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>6000</td>
</tr>
<tr>
<td>2011</td>
<td>7000</td>
</tr>
<tr>
<td>2012</td>
<td>8000</td>
</tr>
<tr>
<td>2013</td>
<td>9000</td>
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<td>2016</td>
<td>12000</td>
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<td>2017</td>
<td>13000</td>
</tr>
<tr>
<td>2018</td>
<td>14000</td>
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</tbody>
</table>

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How to manage the uncertainty?

Common approach: Mean absolute or mean squared error optimized point-forecast
How to manage the uncertainty?

Misconceptions:

• Point-forecasts are often given too much confidence
  • “Your forecast is always wrong” implies the expectation that the forecast needs to be “right”

• The measures of forecast error, whether it be MAPE, WMAPE, MAE, RMSE or any similar metric, all assume that the perfect forecast can be expressed as a single number

How can we do better?

• Transparency
  • No “black box” models
  • What is the Input/output data?

• Uncertainty
  • While we can’t predict wind power production perfectly due to its inherent weather variability, we can predict the weather variability
  • Maximizing the likelihood of a correct prediction rather than minimizing the imbalance / variance
Volume ≠ Value

- Forecasts optimized on error metrics like MAE, RMSE aim to reduce the imbalance volume / the variance
- When selling 1 MW throughout whole 2019 in the Dutch Imbalance Market, 50% of the profit is generated in just 20% of the time
- Imbalance price distribution is asymmetrical
  - Mean = 40.87 EUR
  - Median = 31.46 EUR
- Imbalance price distribution has fat tails -> the extreme values have the biggest impact
"...‘If you go out in the evening with a shotgun and see two flocks of ducks, and you aim for the least-squares location, you will go home hungry’ Miller says. The maximum-likelihood approach is to aim for one of the flocks instead...”

Source: “Ensemble Kalman Filters Bring Weather Models Up to Date”, Dana Mackenzie, SIAM News, Volume 36, Number 8, October 2003
## Probabilistic forecasting methods

### Physical

- Numerical weather prediction ensembles
  - e.g. ECMWF ensemble forecast:
    - Uncalibrated
    - Not valid for very short-term

### Statistical

#### Estimation of quantiles
- Quantile regression
  - No assumptions about the distribution of the residuals

#### Prediction intervals
- Range of coverage probabilities assuming normally distributed forecast errors
  - Preventing quantile crossing can become difficult
  - Uncertainty expressed in one number
  - Symmetric distribution

#### Full density functions
- Parametric
  - E.g. process is assumed to be Gaussian
- Non-parametric
  - Kernel density estimation
  - Analog Ensembles
  - Bayesian methods
  - Can be computationally expensive
Probabilistic forecasting methods

Optimized bids of a Belgium Wind farm using stochastic optimization models

Input data:

Day-ahead wind power forecast

Day-ahead & imbalance prices

Wind power [MW]

Day-ahead price

Imbalance price

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Stochastic Process Modeling

**Approach:** model forecast errors as stochastic processes using conditional Kernel Density (CKD) estimation

Source: Gerrit Deen, 2019, “Increasing the Market Value of Wind Power Using Improved Stochastic Process Modeling and Optimization”
Optimized bids of a Belgium Wind farm

Results

**Optimized bids**

**Forecast error vs. Revenue**

*Conclusions:*
- Higher MAE & higher revenue ($\rightarrow$ Volume ≠ Value)
- Reduced total system costs
- Reduced risk of extreme system imbalance

*Source: Gerrit Deen, 2019, “Increasing the Market Value of Wind Power Using Improved Stochastic Process Modeling and Optimization”*
Thank you!

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