Generation of Synthetic Time Series of Wind Power and Prediction Error for Economic Calculations.

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PRESENTATION OUTLINE

WIND CHARACTERISTICS

- Wind energy in power markets
- Need for accurate predictions + current status

SYNTHETIC TIME SERIES

- Characteristics important for various applications
- Often lack of real data → generate representative data series

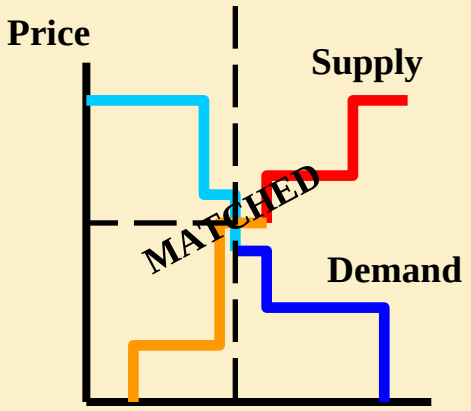
EUROPE'S CHANGING POWER MARKETS

IN THE PAST

- Vertically integrated utilities:
  - Production
  - Transmission
  - Distribution

TODAY

- Open national markets
  - Many traders / retailers
  - Few generators per country
- Self-dispatch
  - Balance responsible parties (ARP)



IMBALANCE PRICES IN BELGIUM

Real production of a portfolio can differ from ARP nomination

→ Imbalance prices

- Production < nominated → buy difference at higher price
- Production > nominated → sell difference at lower price

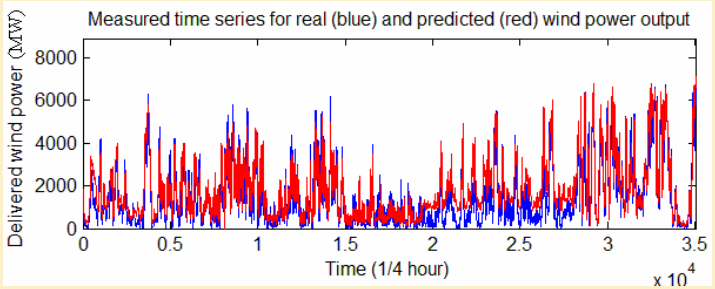
Prices depend on how ARP imbalance influences control energy requirements

	Netto grid – balance requirement	**Netto grid + balance requirement**
ARP +	+ (0 ↗ 92%)	+ 92%
ARP -	- 108%	- (108% ↗ ...)

WIND POWER MARKET CHARACTERISTICS

CURRENT STATUS

- Variable output
- Limited predictability
- Must-run generation (zero marginal cost)



⇒ Market value unknown (imbalance prices)

⇒ Not always taken into account for unit commitment

⇒ Need for wind power predictions

WIND POWER PREDICTIONS:
PREVISIBILITY AND CORRELATION

... the shorter ahead the better.

SINGLE WIND FARM

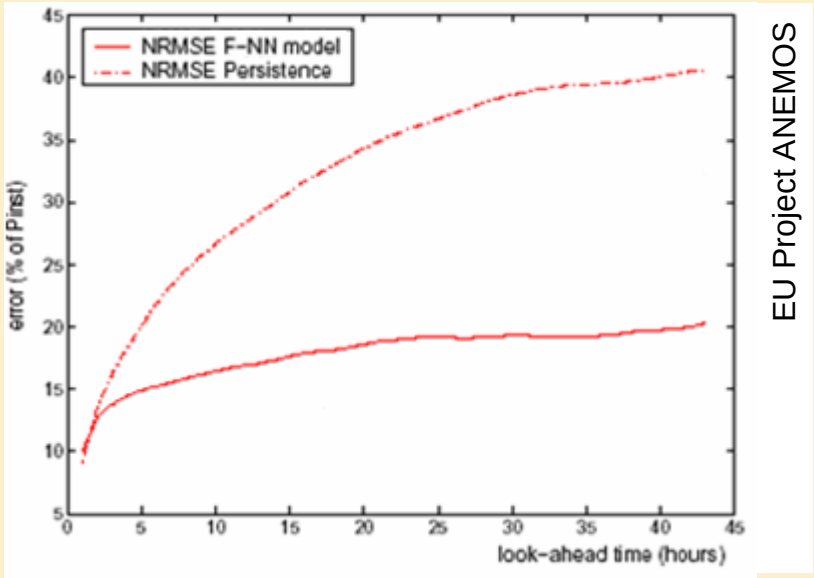
- Day-ahead: RMSE ~10-15%
- 3h ahead: << 10%

PER CONTROL AREA

- Day-ahead: 5-6%
- Intra-day: 3% possible

NEED FOR INTRA-DAY ADJUSTMENT

- Import/export
- Within portfolio management
- Intra-day market



SYNTHETIC TIME SERIES

Many actors interested in time series data

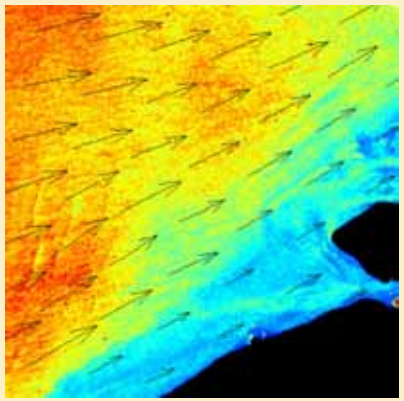
- Wind farm developers (business plans)
- Wind farm operators
- Balance responsible parties & traders
- Power system operators for planning
- Turbine manufacturers
- Research

SYNTHETIC TIME SERIES

- Strong interest in time series
  - Real data costly or difficult to find
  - Available series often not long enough
  - …

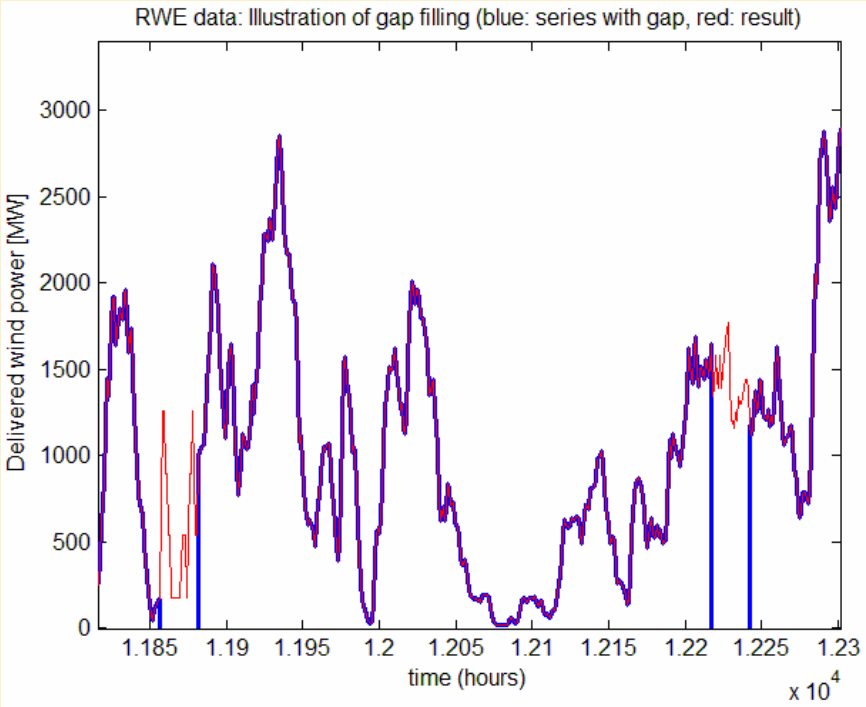
➔ Generation of synthetic time series
(same statistical properties as input series :
mean, variance, autocorrelation)

  - Wind power generation (local/global)
  - Wind power forecast
  - Prices of power and imbalance



SYNTHETIC TIME SERIES

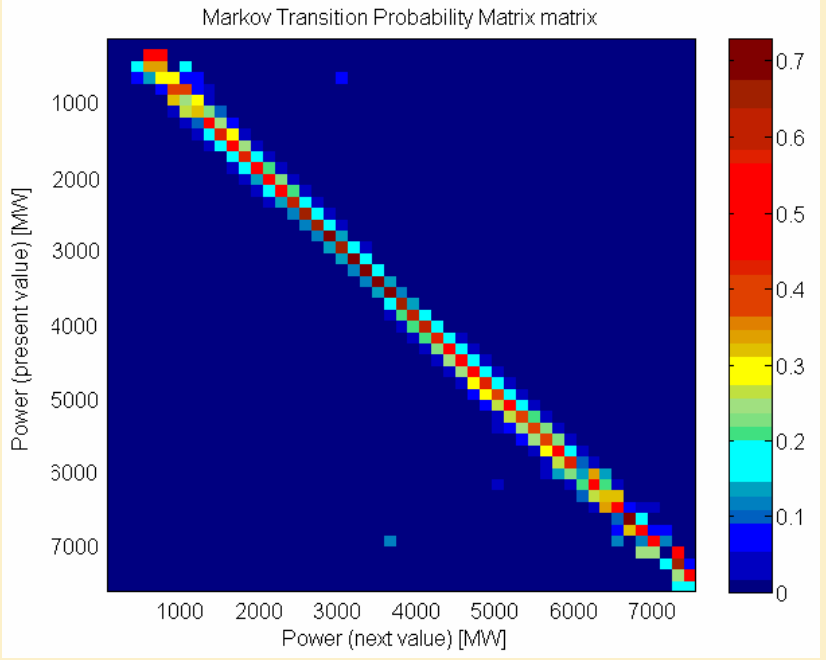
- Applications
  - Economic calculations
  - Unit commitment-, power flow-, simulation- models
  - Gap filling of time series
  - Fatigue load calculations
  - …

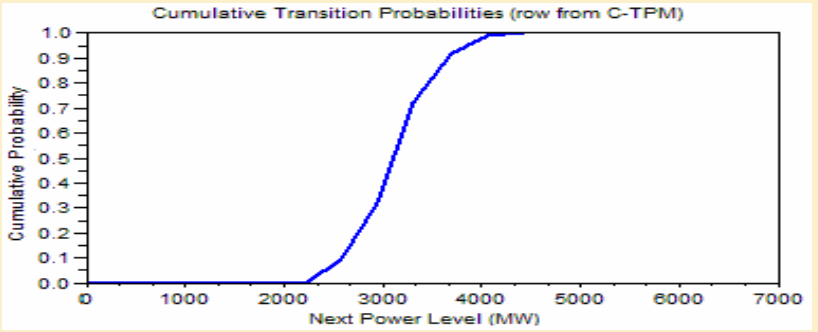


GENERAL METHOD

Markov Chains

1. Split input data into power intervals
2. Count transitions for each interval
   → Transition Probability Matrix (TPM)
3. Compute cumulative TPM (CTPM)
4. Generate random numbers in [0..1]
5. Combine 3 & 4 → Generate series

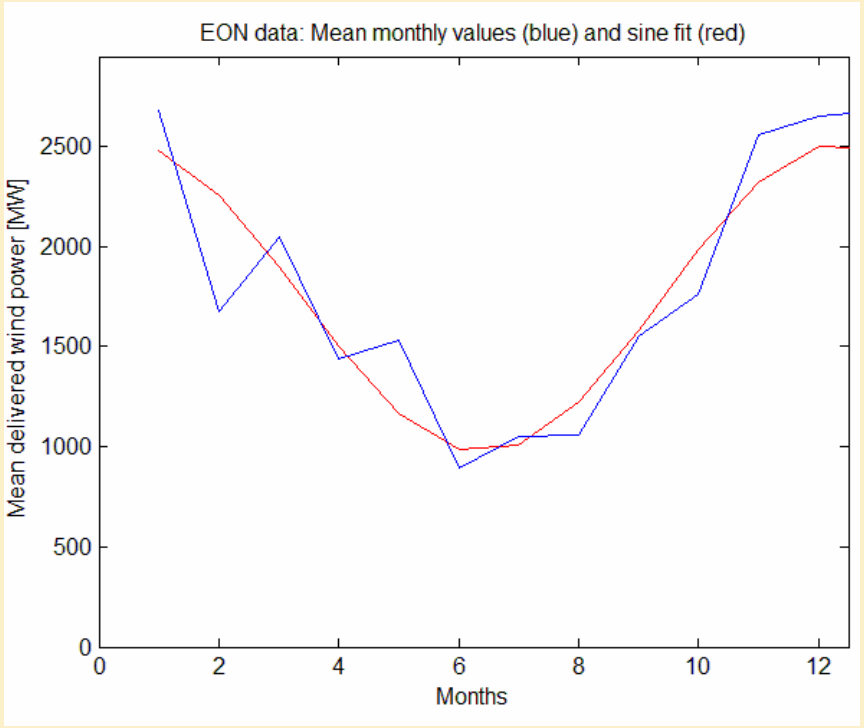


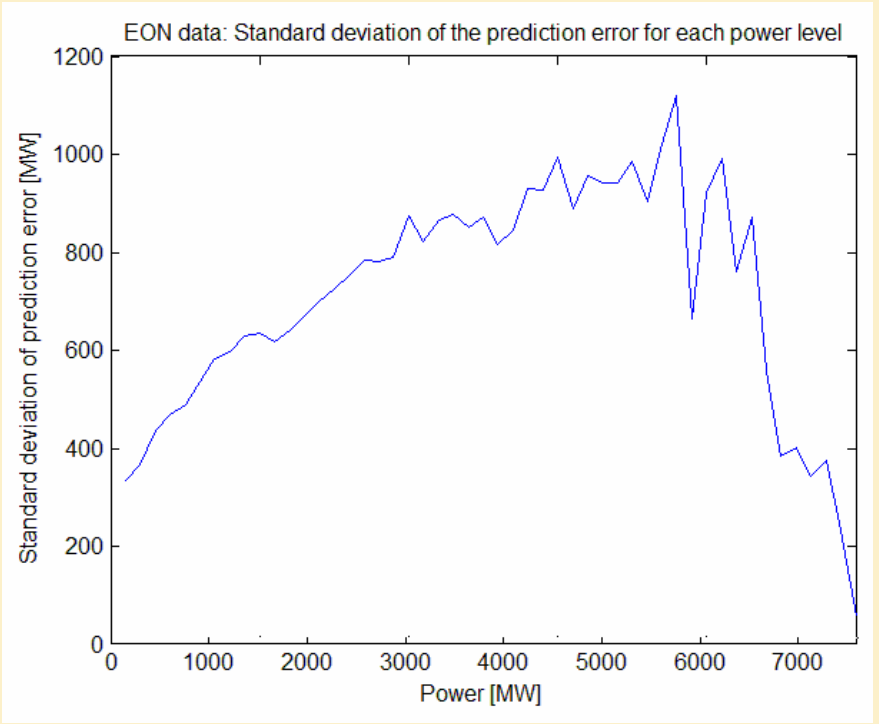


TIME SERIES FOR WIND POWER AND PREDICTION ERROR

Special attention:

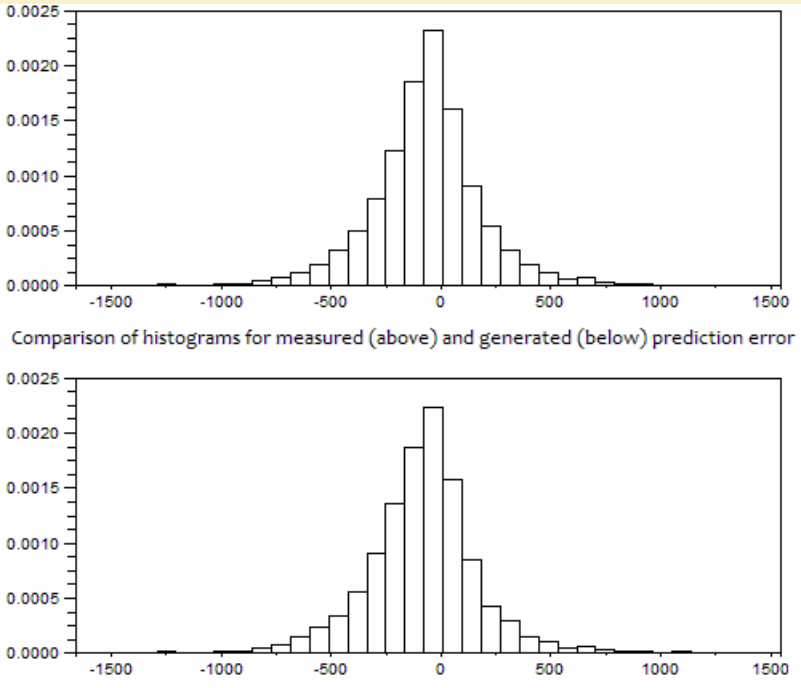
Seasonal variation & Power-error dependency

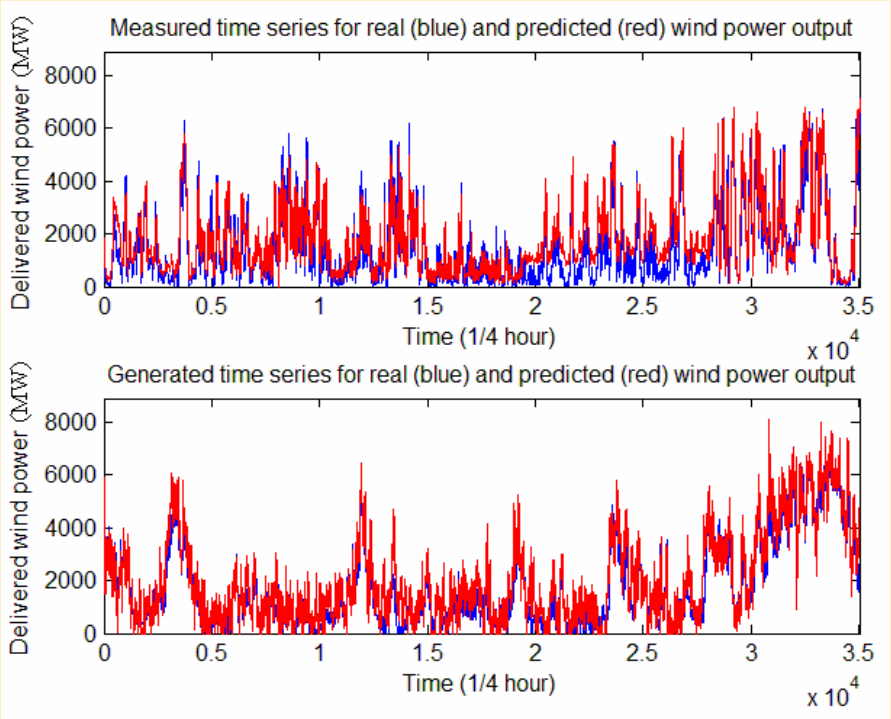




RESULTS

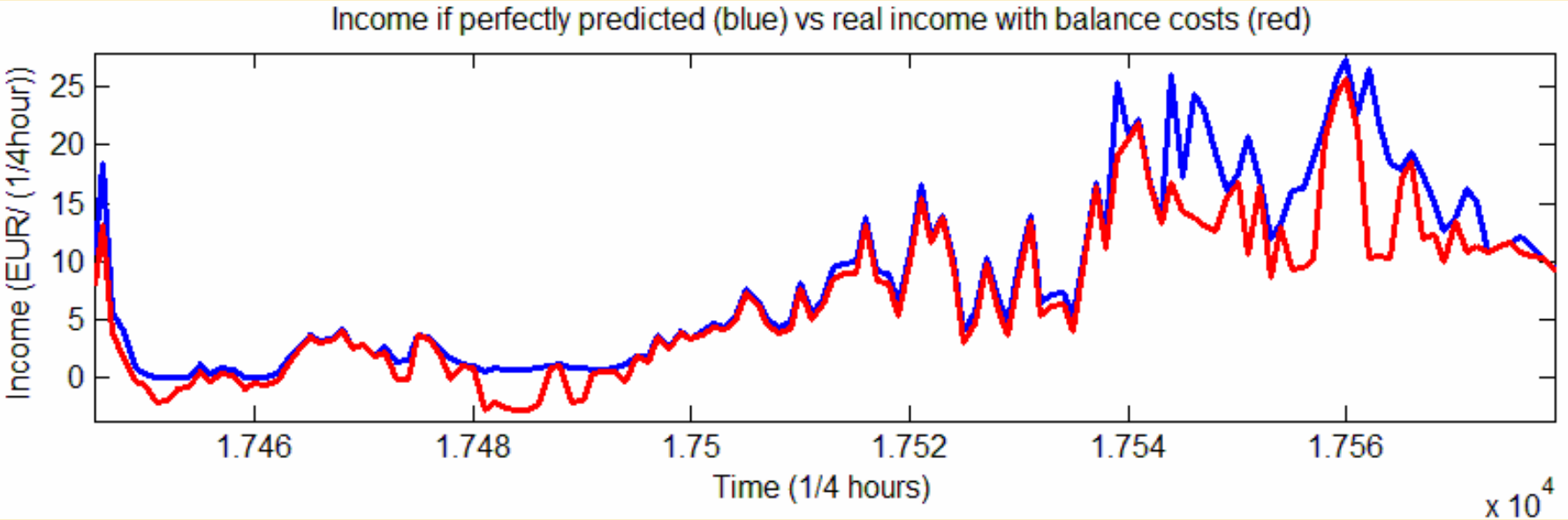
Synthetic time series generation is working properly!





EXAMPLE: IMBALANCE RESULTS

→ Loss of spot market value due to balance costs



CONCLUSIONS

- Changing markets create new challenges for market players
- Balancing a wind portfolio → need for wind power predictions
- Quality of current forecasts 3-15% RMSE
- Wind power market characteristics can be captured to generate synthetic time series

Thank you for your attention!