Trading strategies

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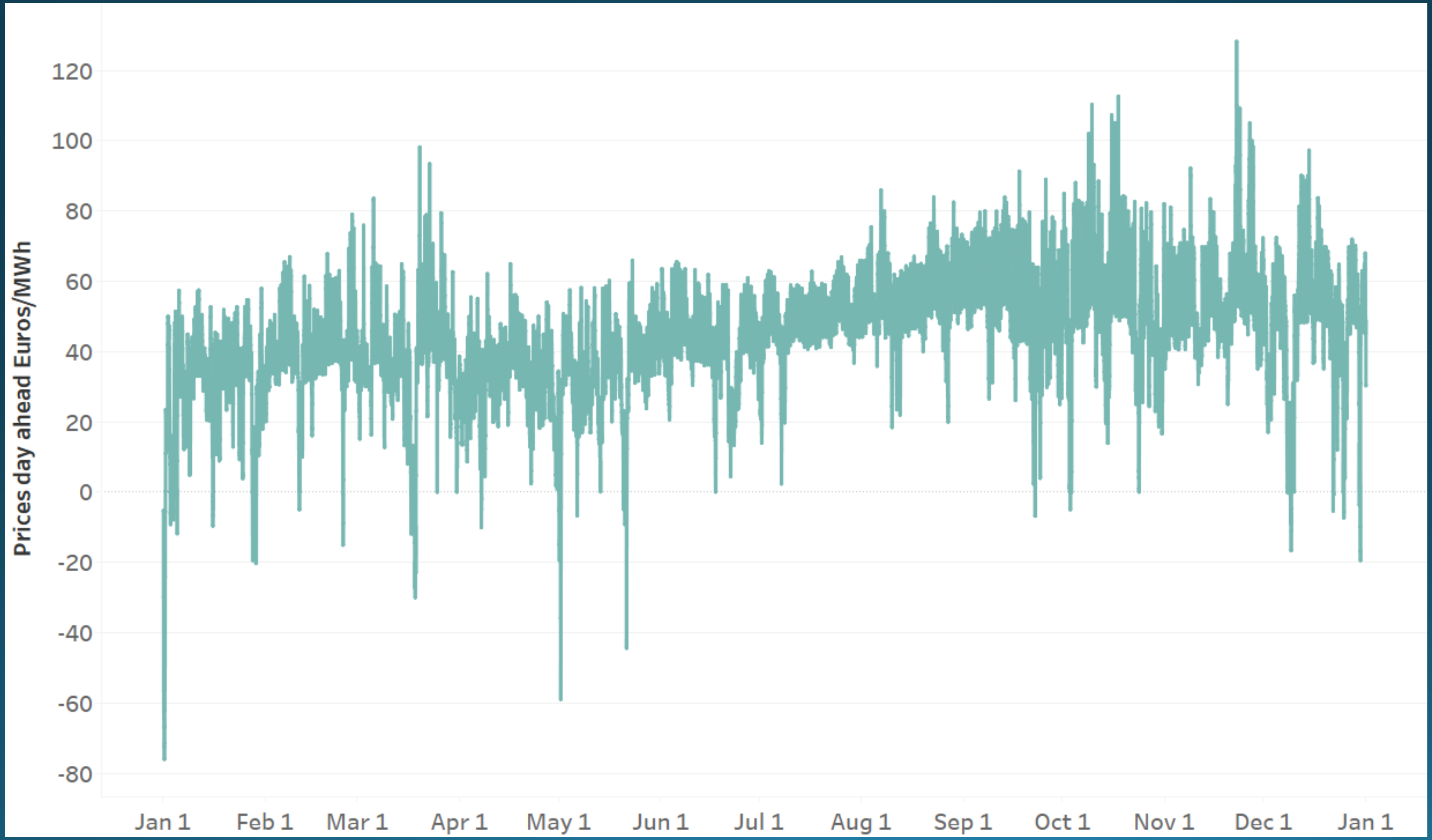
Datasets

- DE Consumption Forecast and Actuals
- DE Production per type Actuals
- Wind and Solar Forecasts
- SPOT Day Ahead prices
- Intraday Prices

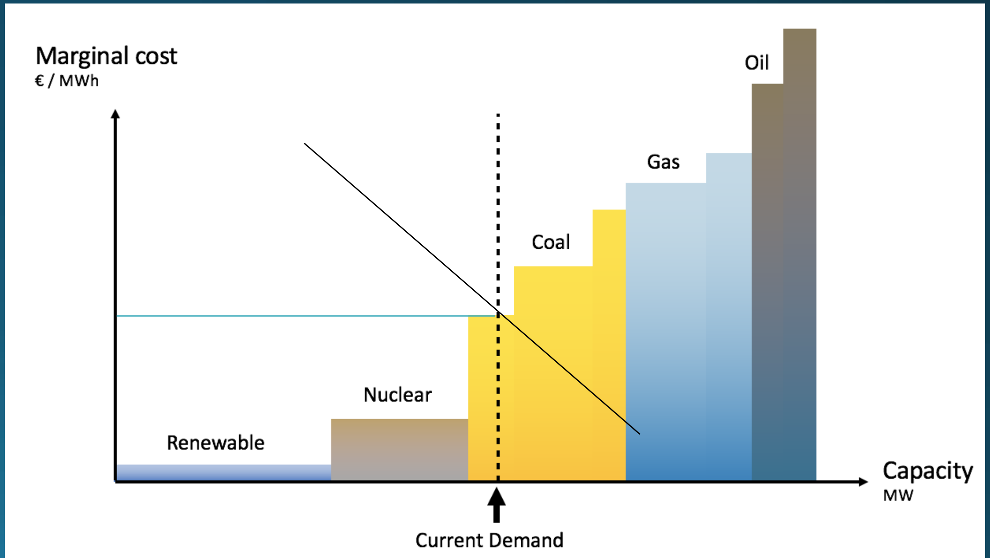
Spot / Day Ahead market

- Commodity market – electricity



Spot / Day Ahead market

- Merit order of generation technologies
- Carbon tax
- More renewables



Spot / Day Ahead market

- Linear regression
  - Scenario 1: Forecasts & Nuclear
  - Scenario 2: Forecasts & Generation technologies

- Criteria
  - P-value < 0.05
  - Adj R-squared
  - Collinearity

Spot / Day Ahead market

- Scenario 1: Forecasts & Nuclear

	Coefficient	Std. Error	t-ratio	p-value	
constant	33.6412	0.580889	57.91	<0.0001	
Total Load Forecast	0.00116623	6.95719e-06	167.6	<0.0001	
Geothermal	−6.29486	0.0493291	−127.6	<0.0001	
Nuclear	−0.00167035	5.86681e-05	−28.47	<0.0001	
Solar forecast	−0.000936662	8.66201e-06	−108.1	<0.0001	
Wind Offshore Forecast	0.00131139	4.85137e-05	27.03	<0.0001	
Wind Onshore Forecast	−0.00167005	9.06951e-06	−184.1	<0.0001	
Tuesday	−0.882202	0.151281	−5.832	<0.0001	
Wednesday	−1.55938	0.151621	−10.28	<0.0001	
Sunday	−1.06825	0.161010	−6.635	<0.0001	

Mean dependent var	44.42605		S.D. dependent var	17.75677
Sum squared resid	3035784		S.E. of regression	9.401641
R-squared	0.719737		Adjusted R-squared	0.719663

Spot / Day Ahead market

- Scenario 2: Forecasts & Generation technologies

	Coefficient	Std. Error	t-ratio	p-value
const	76.3443	1.22414	62.37	<0.0001
Geothermal	−3.95308	0.0553215	−71.46	<0.0001
Solar Forecast	−0.000116042	7.12652e-06	−16.28	<0.0001
Wind Offshore Forecast	0.000794323	4.61147e-05	17.22	<0.0001
Wind Onshore Forecast	−0.000721417	9.26154e-06	−77.89	<0.0001
Biomass	−0.00789675	0.000251447	−31.41	<0.0001
Brown coal Lignite	0.00106343	2.41633e-05	44.01	<0.0001
Gas	0.000674510	4.27347e-05	15.78	<0.0001
Hard coal	0.000724879	1.89081e-05	38.34	<0.0001
Hydro Pumped Storage	0.00202475	4.12984e-05	49.03	<0.0001
Hydro Pumped Storage Consumption	−0.00293797	4.41206e-05	−66.59	<0.0001
Thursday	1.91106	0.133748	14.29	<0.0001
Friday	2.49749	0.137844	18.12	<0.0001
Oil	0.0167166	0.000293098	57.03	<0.0001
Hydro Water Reservoir	0.0155708	0.000636614	24.46	<0.0001
Hydro Run of river and poundage	−0.00398889	0.000187419	−21.28	<0.0001

Mean dependent var	44.19116	S.D. dependent var	17.80390
Sum squared resid	2193006	S.E. of regression	8.152594
R-squared	0.790413	Adjusted R-squared	0.790318

Spot / Day Ahead market

- Scenario 2: Correlation

	Day Ahead price
Hard coal	0.6659
Gas	0.5557
Brown Coal	0.5252
Wind onshore Forecast	-0.5017
Hydro pump storage consumption	-0.4707
Hydro pump storage	0.4167
Hydro water reservoir	0.3972
Oil	0.3817
Geothermal	-0.3527
Hyro run of river	-0.3124

Spot / Day Ahead market

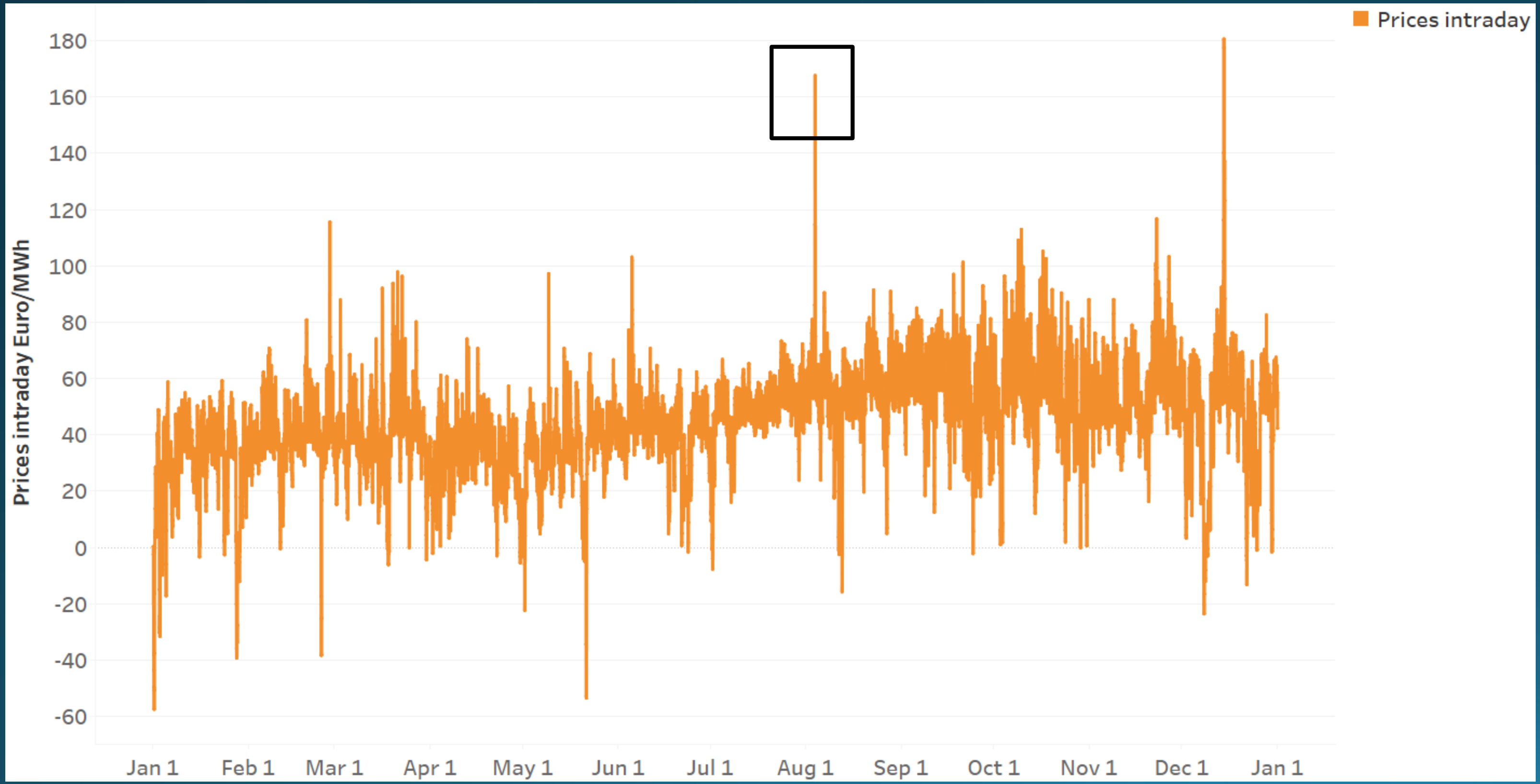
- Depends on the merit order.
- Price setters.

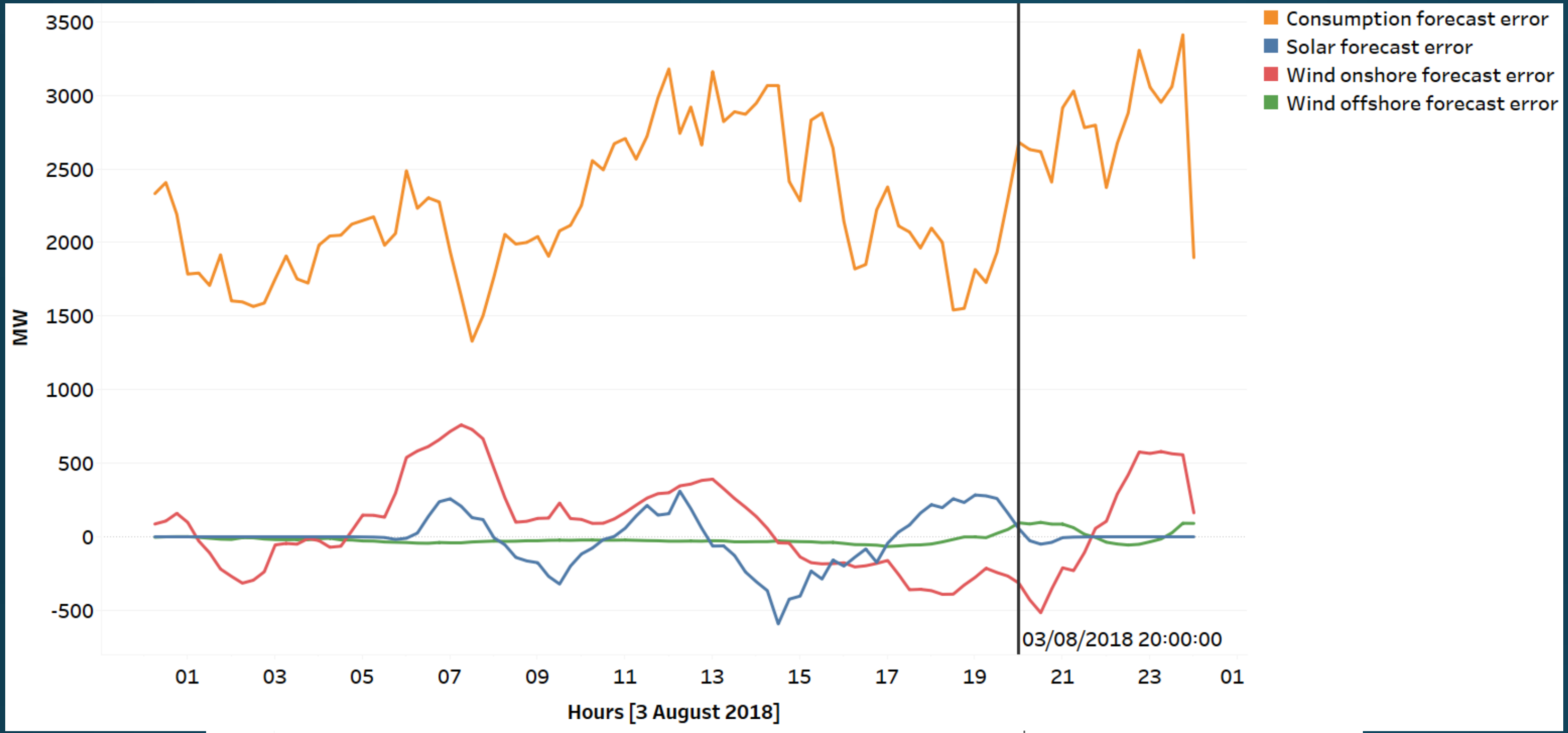
Intraday market

- Imbalance market
- Forecasting errors

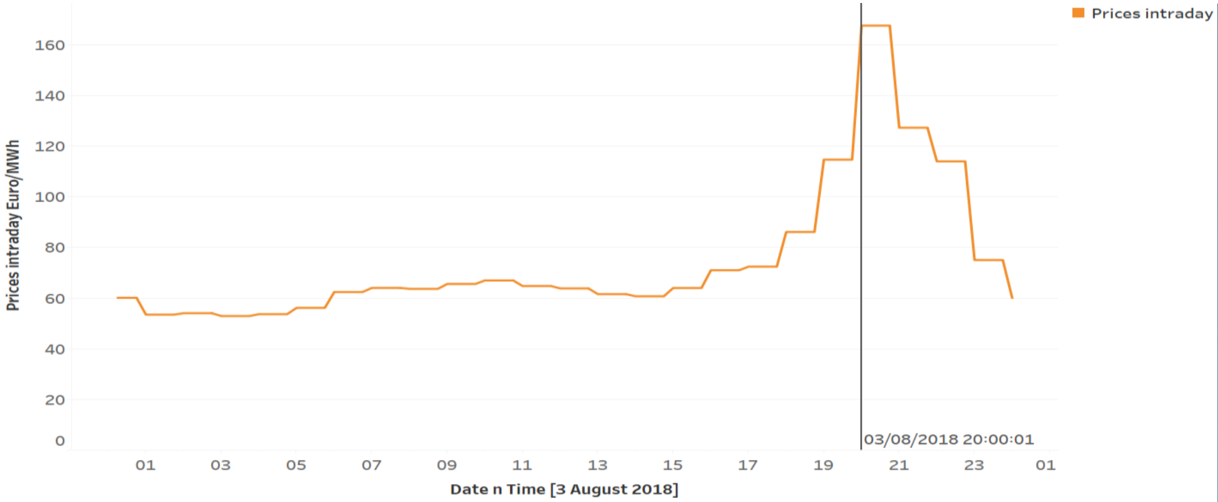
Intraday market

- Forecasting errors





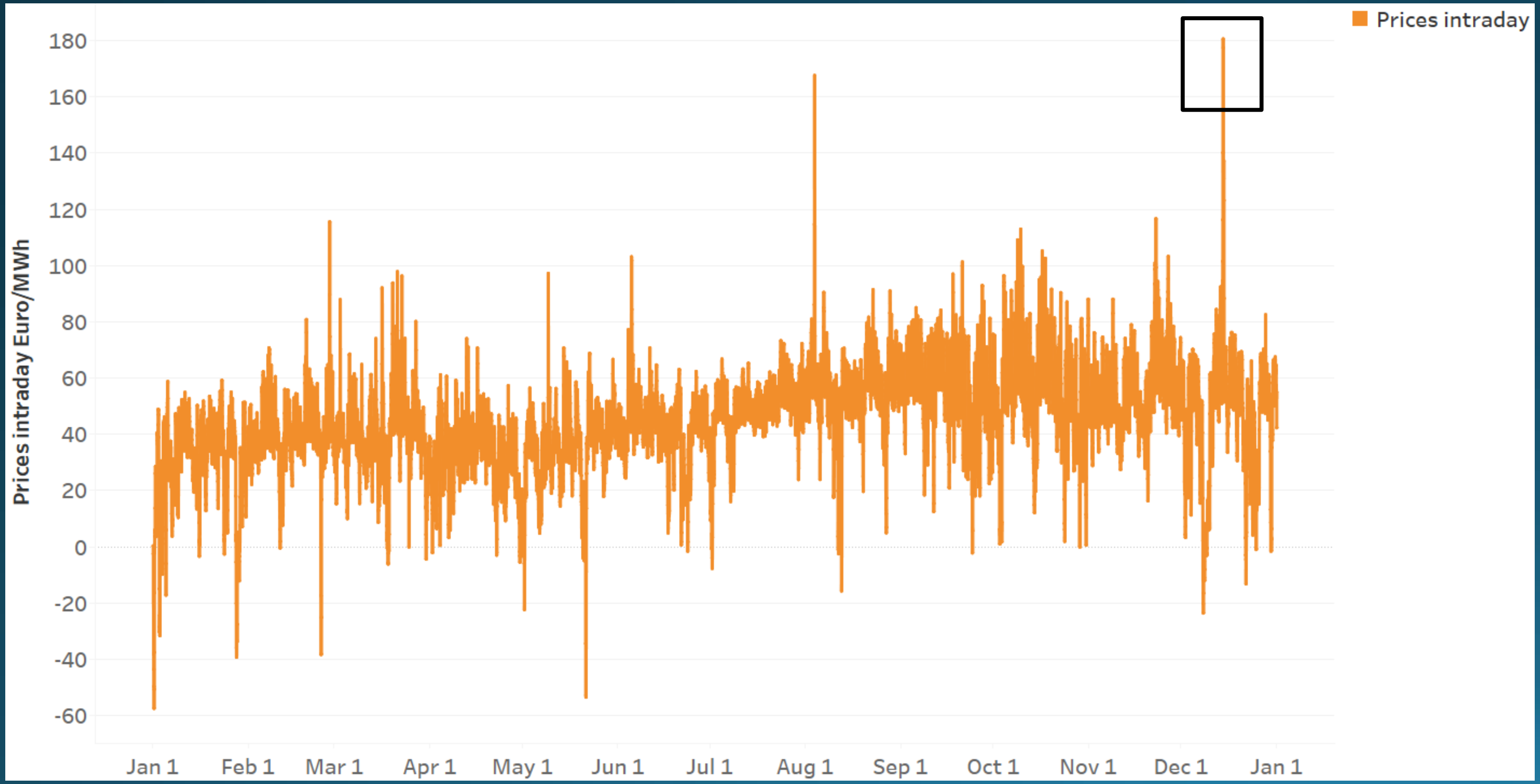
Consumption forecast error
Solar forecast error
Wind onshore forecast error
Wind offshore forecast error
MW
3500
3000
2500
2000
1500
1000
500
0
-500
03/08/2018 20:00:00
01 03 05 07 09 11 13 15 17 19 21 23 01
Hours [3 August 2018]

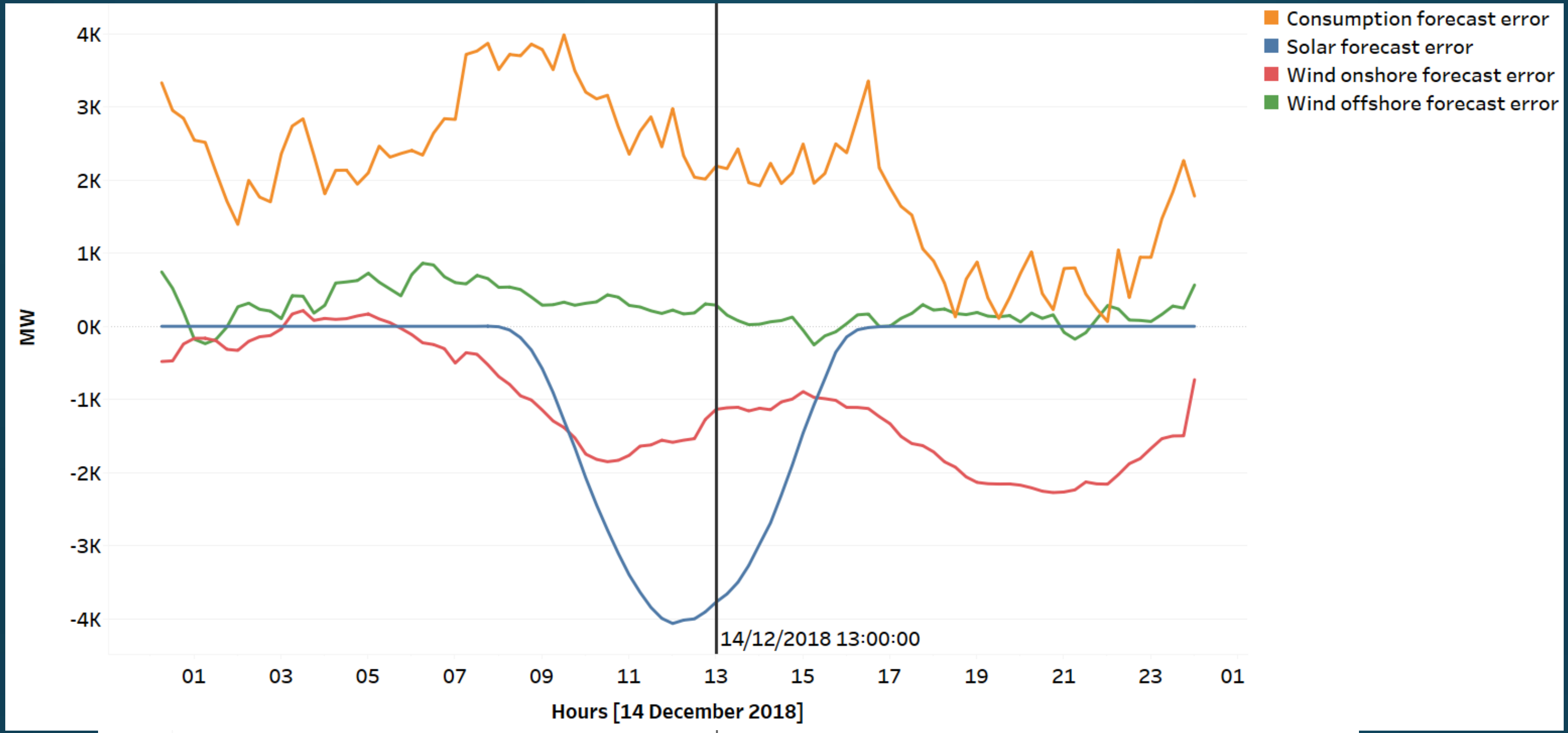


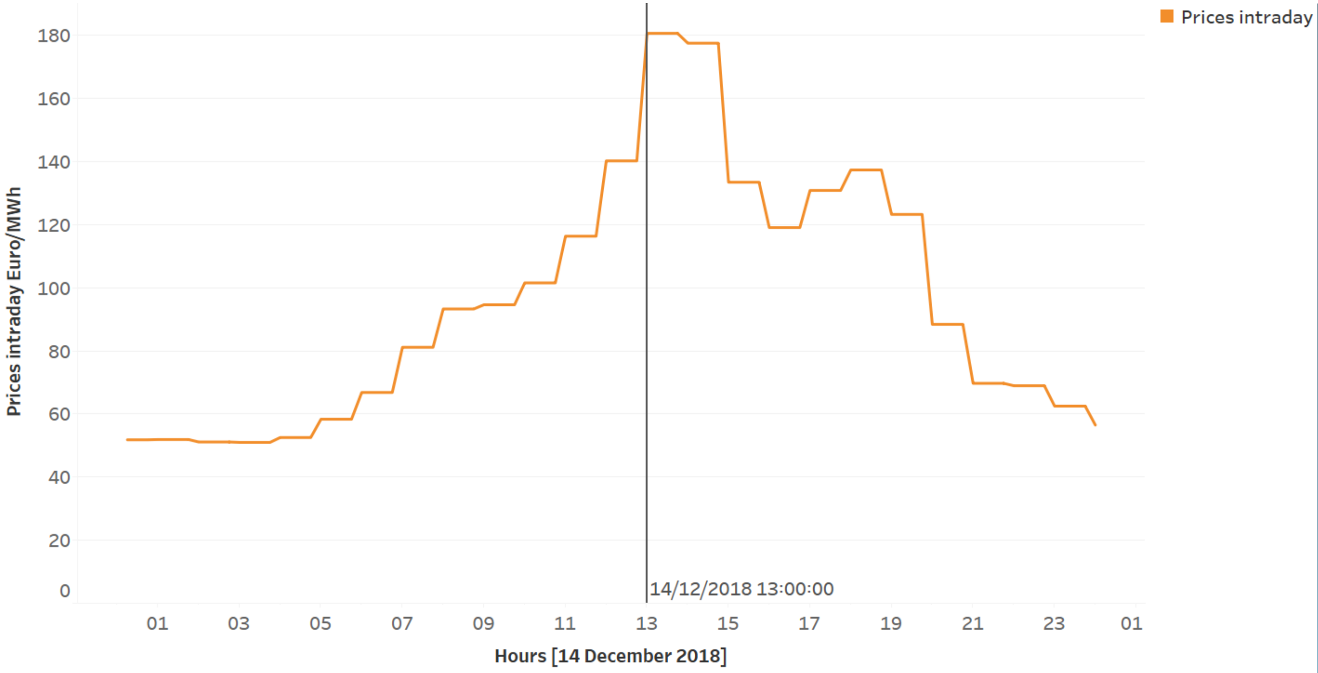
Prices intraday
Prices intraday Euro/MWh
160
140
120
100
80
60
40
20
0
03/08/2018 20:00:01
01 03 05 07 09 11 13 15 17 19 21 23 01
Date n Time [3 August 2018]

Intraday market

- Forecasting errors




Consumption forecast error
Solar forecast error
Wind onshore forecast error
Wind offshore forecast error
MW
4K
3K
2K
1K
0K
-1K
-2K
-3K
-4K
14/12/2018 13:00:00
01 03 05 07 09 11 13 15 17 19 21 23 01
Hours [14 December 2018]


Prices intraday
Prices intraday Euro/MWh
180
160
140
120
100
80
60
40
20
0
14/12/2018 13:00:00
01 03 05 07 09 11 13 15 17 19 21 23 01
Hours [14 December 2018]

Intraday market

- Linear regression
  - Scenario 1: Forecasts
  - Scenario 2: Forecasts & Day Ahead price
  - Scenario 3: Forecasts Errors & Day Ahead price

Intraday market

- Scenario 1: Forecasts

	Coefficient	Std. Error	t-ratio	p-value
const	34.0932	0.700133	48.70	<0.0001
Load Forecast	0.00117901	8.63789e-06	136.5	<0.0001
Solar Forecast	−0.000920578	1.05105e-05	−87.59	<0.0001
Wind Offshore Forecast	0.00157836	5.84822e-05	26.99	<0.0001
Wind Onshore Forecast	−0.00160376	1.09358e-05	−146.7	<0.0001
Geothermal	−6.19542	0.0594443	−104.2	<0.0001
Nuclear	−0.00195656	7.07819e-05	−27.64	<0.0001
Tuesday	−1.28848	0.202009	−6.378	<0.0001
Wednesday	−1.81445	0.202652	−8.954	<0.0001
Thrusday	0.425045	0.200805	2.117	0.0343
Friday	−0.588374	0.206029	−2.856	0.0043
Sunday	−2.87306	0.204188	−14.07	<0.0001

Mean dependent var	44.56949	S.D. dependent var	18.57450
Sum squared resid	4404024	S.E. of regression	11.32613
R-squared	0.628302	Adjusted R-squared	0.628183

Intraday market

- Scenario 2: Forecasts & Day Ahead price

	Coefficient	Std. Error	t-ratio	p-value
const	3.20329	0.475369	6.739	<0.0001
Total Load Forecast	0.000112246	7.36747e-06	15.24	<0.0001
Solar Forecast	−6.26643e-05	7.85310e-06	−7.980	<0.0001
Wind Offshore Forecast	0.000377297	3.82973e-05	9.852	<0.0001
Wind Onshore forecast	−7.18319e-05	9.98684e-06	−7.193	<0.0001
Geothermal	−0.421487	0.0467705	−9.012	<0.0001
Nuclear	−0.000427197	4.63943e-05	−9.208	<0.0001
Prices day ahead	0.917403	0.00421310	217.8	<0.0001
Tuesday	−0.607030	0.122225	−4.967	<0.0001
Wednesday	−0.512579	0.122670	−4.179	<0.0001
Friday	−0.640797	0.125051	−5.124	<0.0001
Sunday	−1.98747	0.127905	−15.54	<0.0001

Mean dependent var	44.56949	S.D. dependent var	18.57450
Sum squared resid	1849805	S.E. of regression	7.340400
R-squared	0.843877	Adjusted R-squared	0.843827

Intraday market

- Scenario 2: Forecasts Errors & Day Ahead price

	Coefficient	Std. Error	t-ratio	p-value
const	2.35989	0.0978015	24.13	<0.0001
Consumption error	0.000314905	1.60153e-05	19.66	<0.0001
Solar error	−0.00294973	4.64439e-05	−63.51	<0.0001
Wind onshore error	−0.00229688	2.25746e-05	−101.7	<0.0001
Wind offshore error	−0.00307611	5.84445e-05	−52.63	<0.0001
Prices day ahead	0.944740	0.00185234	510.0	<0.0001
Wednesday	0.433338	0.0943830	4.591	<0.0001
Thrusday	0.248897	0.0936120	2.659	0.0078
Sunday	−1.27919	0.0979232	−13.06	<0.0001

Mean dependent var	44.56949	S.D. dependent var	18.57450
Sum squared resid	1183217	S.E. of regression	5.870432
R-squared	0.900137	Adjusted R-squared	0.900114

Intraday market

Scenario	Adj R-Squared
1. Forecasts	0.628183
2. Forecasts & Day Ahead price	0.843827
3. Forecasts Errors & Day Ahead price	0.900114

Trading strategy

- Cross country trading
  - DE intraday prices > FR day ahead prices : 2912 hours (33%)
  - Cross border capacity allocation

Trading strategy

- Within DE trading
  - DE intraday prices > DE day ahead prices : 4377 hours (50%)

- Logistic Regression
  - If intraday price > day ahead price = 1, else 0
  - Three scenarios
    1. Forecasted data & Nuclear
    2. Forecasted data & Day ahead prices
    3. Forecast errors

Trading strategy

- Logistic regression results

Scenario	Accuracy (%) from confusion matrix
1. Forecasted data & Nuclear	56.8
2. Forecasted data & Day ahead prices	56.1
3. Forecast Errors	72.6

Trading strategy

- Trading volumes
  - Small chunks to spread the risk
- Price difference
- Improvements
  - Better prediction model (neural networks)
  - Intraday markets are dynamic
    - Continuous improved forecasts
    - Continuous bidding
  - Power flow between countries

Thank you

Trading Strategy

	Coefficient	Std. Error	z	p-value	
const	0.352219	0.108534	3.245	0.0012	***
DayaheadTotalLoadForecast	−3.92165e-06	1.55971e-06	−2.514	0.0119	**
NuclearActualAggregatedM	−3.89732e-05	1.17126e-05	−3.327	0.0009	***
GenerationSolarMWDayAh	1.26271e-05	1.87659e-06	6.729	<0.0001	***
GenerationWindOffshoreMW	6.56532e-05	1.04220e-05	6.299	<0.0001	***
GenerationWindOnshoreMW	1.77371e-05	1.95858e-06	9.056	<0.0001	***
Tuesday	−0.204361	0.0352185	−5.803	<0.0001	***
Wednesday	−0.153281	0.0352471	−4.349	<0.0001	***
Friday	−0.402008	0.0361103	−11.13	<0.0001	***
Saturday	−0.110087	0.0364887	−3.017	0.0026	***
Sunday	−0.490757	0.0386071	−12.71	<0.0001	***

Number of cases 'correctly predicted' = 19518 (56.8%)
f(beta'x) at mean of independent vars = 0.500
Likelihood ratio test: Chi-square(10) = 659.499 [0.0000]

Trading Strategy

- Sc 2

	Coefficient	Std. Error	z	p-value	
const	0.294751	0.109004	2.704	0.0069	***
DayaheadTotalLoadForecast	6.79523e-06	1.67628e-06	4.054	<0.0001	***
NuclearActualAggregatedM	−2.86917e-05	1.17835e-05	−2.435	0.0149	**
GenerationSolarMWDayAh	3.84244e-06	1.88295e-06	2.041	0.0413	**
GenerationWindOffshoreMW	8.53781e-05	8.50601e-06	10.04	<0.0001	***
Pricesdayahead15min	−0.0100778	0.000767139	−13.14	<0.0001	***
Tuesday	−0.214954	0.0352770	−6.093	<0.0001	***
Wednesday	−0.166135	0.0352731	−4.710	<0.0001	***
Friday	−0.403063	0.0361331	−11.15	<0.0001	***
Saturday	−0.114226	0.0365368	−3.126	0.0018	***
Sunday	−0.511563	0.0387626	−13.20	<0.0001	***

Number of cases 'correctly predicted' = 19289 (56.1%)
f(beta'x) at mean of independent vars = 0.500
Likelihood ratio test: Chi-square(10) = 752.105 [0.0000]

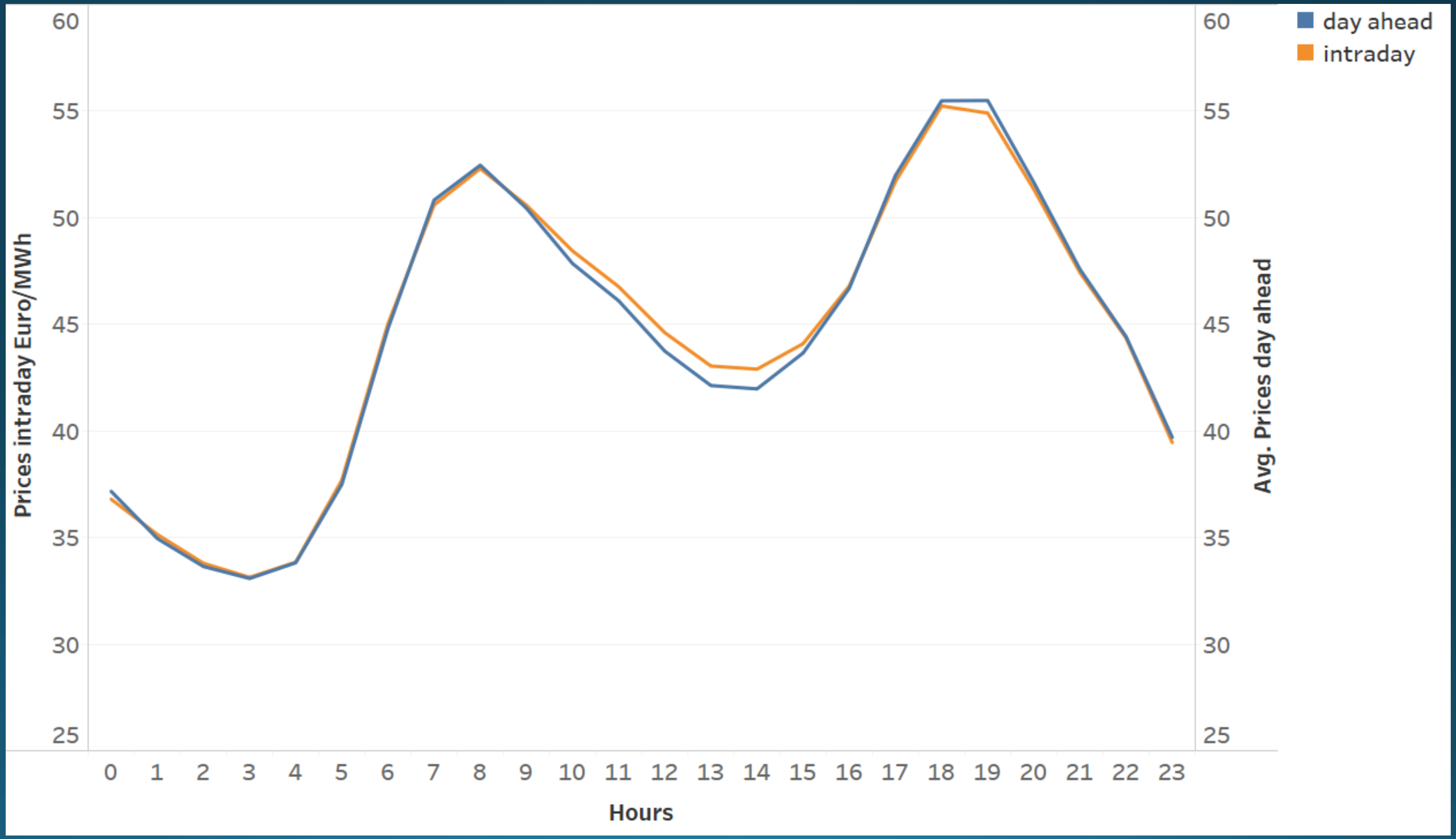
Trading Strategy

- Sc 3

	Coefficient	Std. Error	z	p-value	
const	0.877414	0.0416697	21.06	<0.0001	***
Pricesdayahead15 min	−0.0198612	0.000795767	−24.96	<0.0001	***
Consumptionerror	9.13796e-05	6.57509e-06	13.90	<0.0001	***
Solarerror	−0.00107424	2.49295e-05	−43.09	<0.0001	***
Windonshoreerror	−0.00086251 9	1.26990e-05	−67.92	<0.0001	***
Windoffshoreerror	−0.00098587 5	2.69516e-05	−36.58	<0.0001	***
Wednesday	0.116427	0.0392621	2.965	0.0030	***
Thursday	0.152070	0.0390843	3.891	<0.0001	***
Friday	−0.300397	0.0400498	−7.501	<0.0001	***
Sunday	−0.332368	0.0405918	−8.188	<0.0001	***

Number of cases 'correctly predicted' = 24928 (72.6%)
f(beta'x) at mean of independent vars = 0.500
Likelihood ratio test: Chi-square(9) = 11161.7 [0.0000]

Spot and Intraday price



Spot and Intraday price

- Nov, Dec, Jan