Amsterdam, 9 May 2017
FLAME conference

The Value of Storage

Forecasting storage flows and gas prices

www.kyos.com, +31 (0)23 5510221
Cyriel de Jong, dejong@kyos.com

KYOS Energy Analytics

Analytical solutions for trading, valuation & risk management in energy markets

Name	DE Intrinsic €/MWh	DE Simulation €/MWh	UK Intrinsic £/MWh	UK Simulation £/MWh
Coal 46%	3.38 ↑	5.44 ↑	4.93 ↓	6.11 ↓
Coal 46% option	6.18 ↑	7.93 ↑	7.80 ↓	8.78 ↓
Gas 60%	1.12 ↓	3.91 ↑	6.15 ↓	7.11 ↓
Gas 60% option	1.58 ↓	4.27 ↑	6.79 ↓	7.72 ↓

Market	Product	Period	Option Avg	Option 10%
TTF	30/30	SY2017	3.00 ↓	2.30
TTF	60/60	SY2017	1.92 ↓	1.46
TTF	60/120	SY2017	1.47 ↓	1.11
NBP	30/30	SY2017	18.27 ↑	14.83
NBP	60/60	SY2017	12.90 ↑	10.92
NBP	60/120	SY2017	10.72 ↑	9.12

- **Power markets**

Power plant optimization, valuation, hedging

Forward curves and Monte Carlo simulations

- **Gas markets**

Storage and swing contracts valuation and Optimization of gas portfolio assets and contracts

- **Multi-commodity portfolio & risk management**

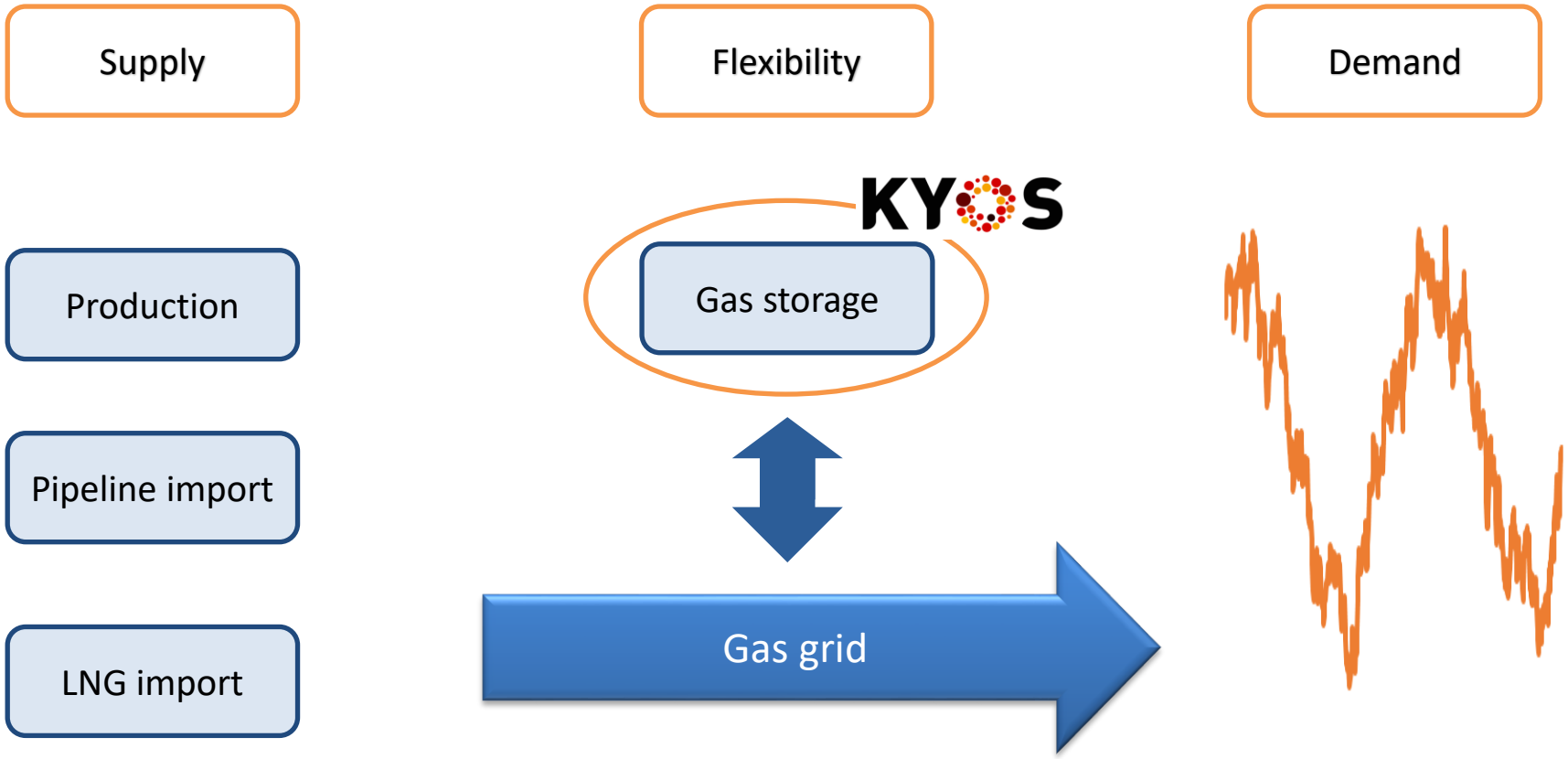
Commodity Trade & Risk Management

At-Risk software: VaR, EaR, CfaR

Free monthly valuation reports: www.kyos.com/knowledge-center

KYOS

The gas value chain: flexibility is key



Stable production, unstable demand, storage mainly used to manage flexibility

Gas storage modeling

- Gas storage modeling software for the optimal management of gas storage assets

- The software reveals:
  - Future: what is the expected market trading value?
  - Medium-term: what are the optimal forward trades?
  - Short-term: inject, withdraw or do nothing?
  - Past: how much money could have been made?

- Methodology: least-squares Monte Carlo
  - Storage is a real option; maximize its flexibility value
  - Using Monte Carlo price simulations, find optimal trades

From storage modeling to forecasting

Goal: predict storage flows and gas market prices

Step 1 & 4: KYOS
Step 2 & 3: clients

Step 1.

Using market prices (forward) and volatility, forecast storage flows

Step 2.

Combine storage flows with forecasts of: gas demand – gas production – gas imports

Step 3.

If balance is short (long), then period is under (over) priced relative to other periods

Step 4.

Forecast market price movement to balance supply – demand

KYOS

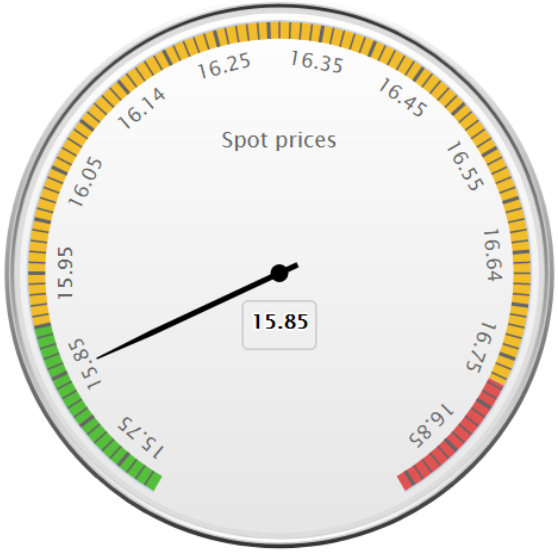
Example: spot trading signal (1 storage)

Slow storage product:

- 1000 MWh working volume, 5% full
- 150 days to fill, 150 days to release (6.67 MWh/day)
- Valuation on 5 May 2017
- Front-month (June) price = 15.82 €/MWh
- Spot price = 15.85 €/MWh

Inject below a spot midprice of:	15.90
Withdraw above a spot midprice of:	16.78

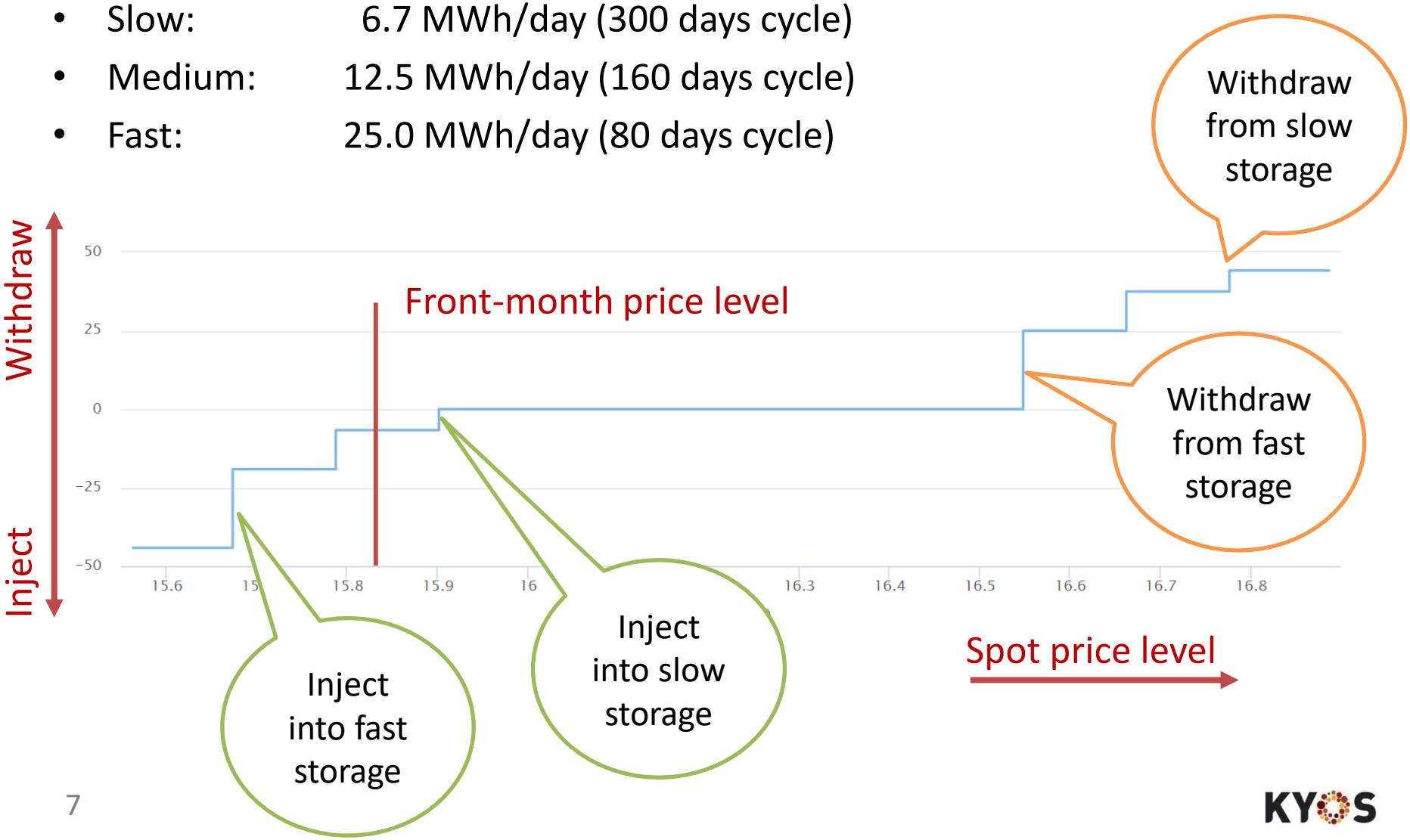
Inject 6.67 MWh.



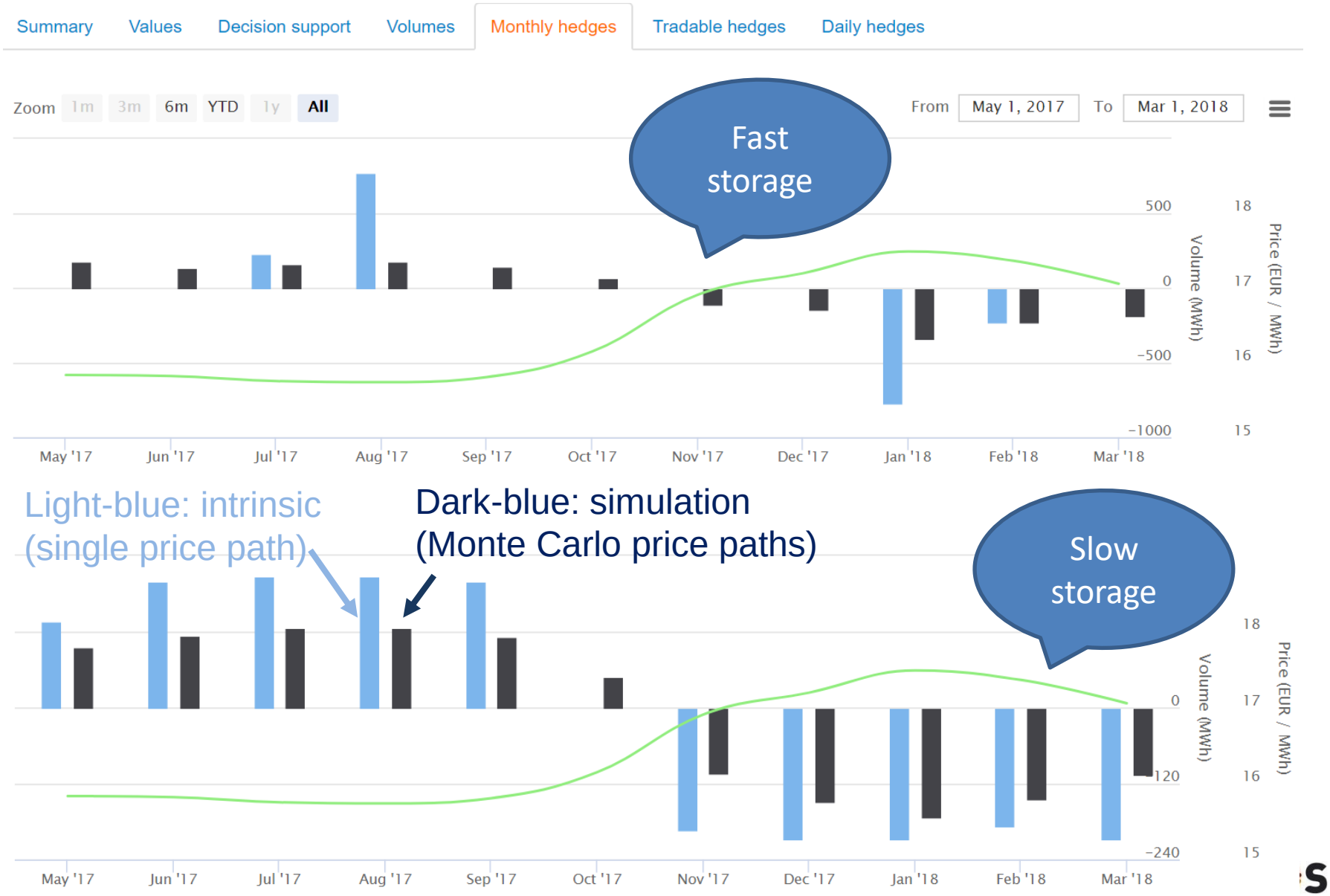
Example: spot trading signal (multiple storages)

3 storage assets, all 1000 MWh working volume:

- Slow: 6.7 MWh/day (300 days cycle)
- Medium: 12.5 MWh/day (160 days cycle)
- Fast: 25.0 MWh/day (80 days cycle)



Forecasted volumes for a gas storage



Research questions

- How well does the KYOS model optimize the trading decisions?
  - Backtesting to see if model's trading decisions create enough extrinsic value

- How well does the KYOS model predict actual storage flows?
  - Some storage assets are optimized in the market
  - Some storage assets are not (much) optimized in the market

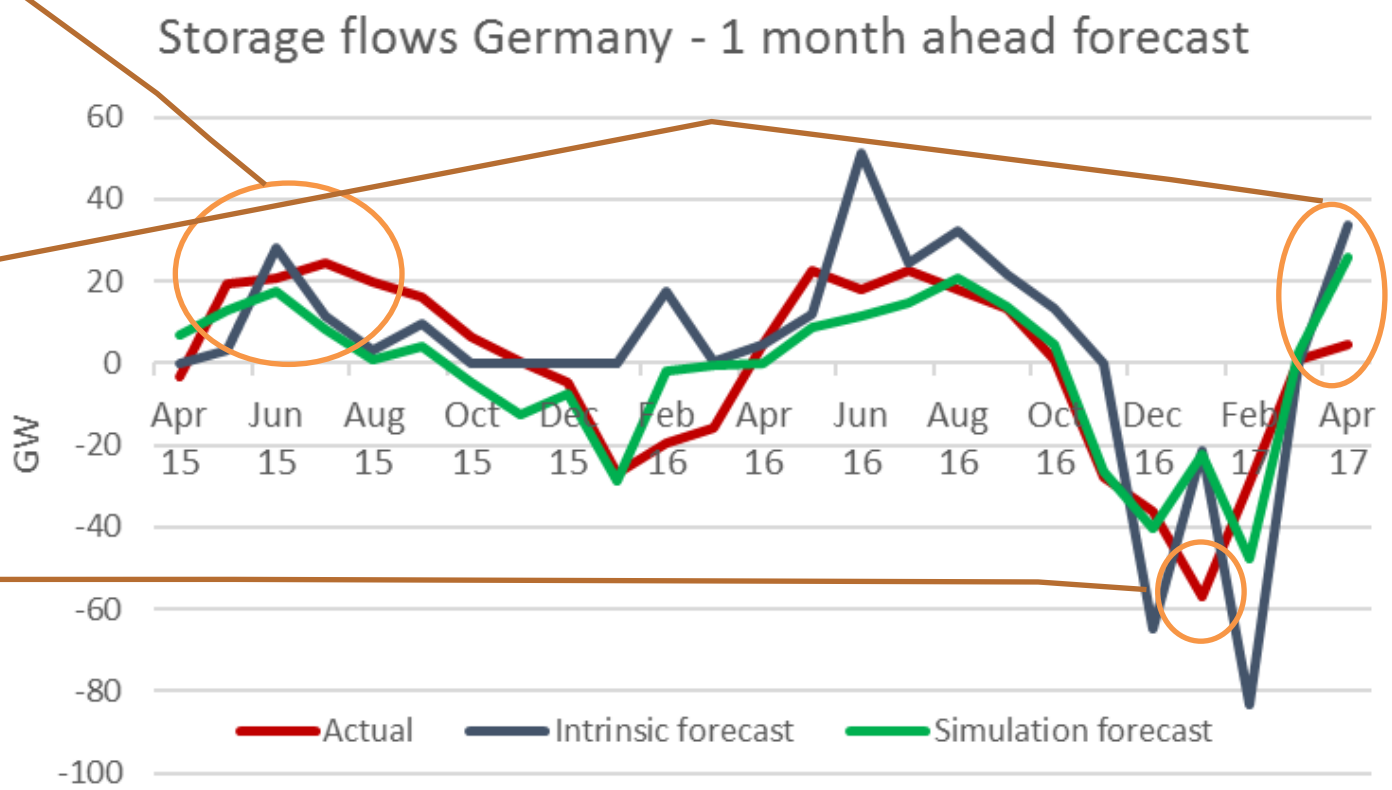
Forecasting DE storage flows 1-month ahead

Simulation based forecast 43% better than intrinsic forecast

Sum-15: falling market prices; spot lower than expected

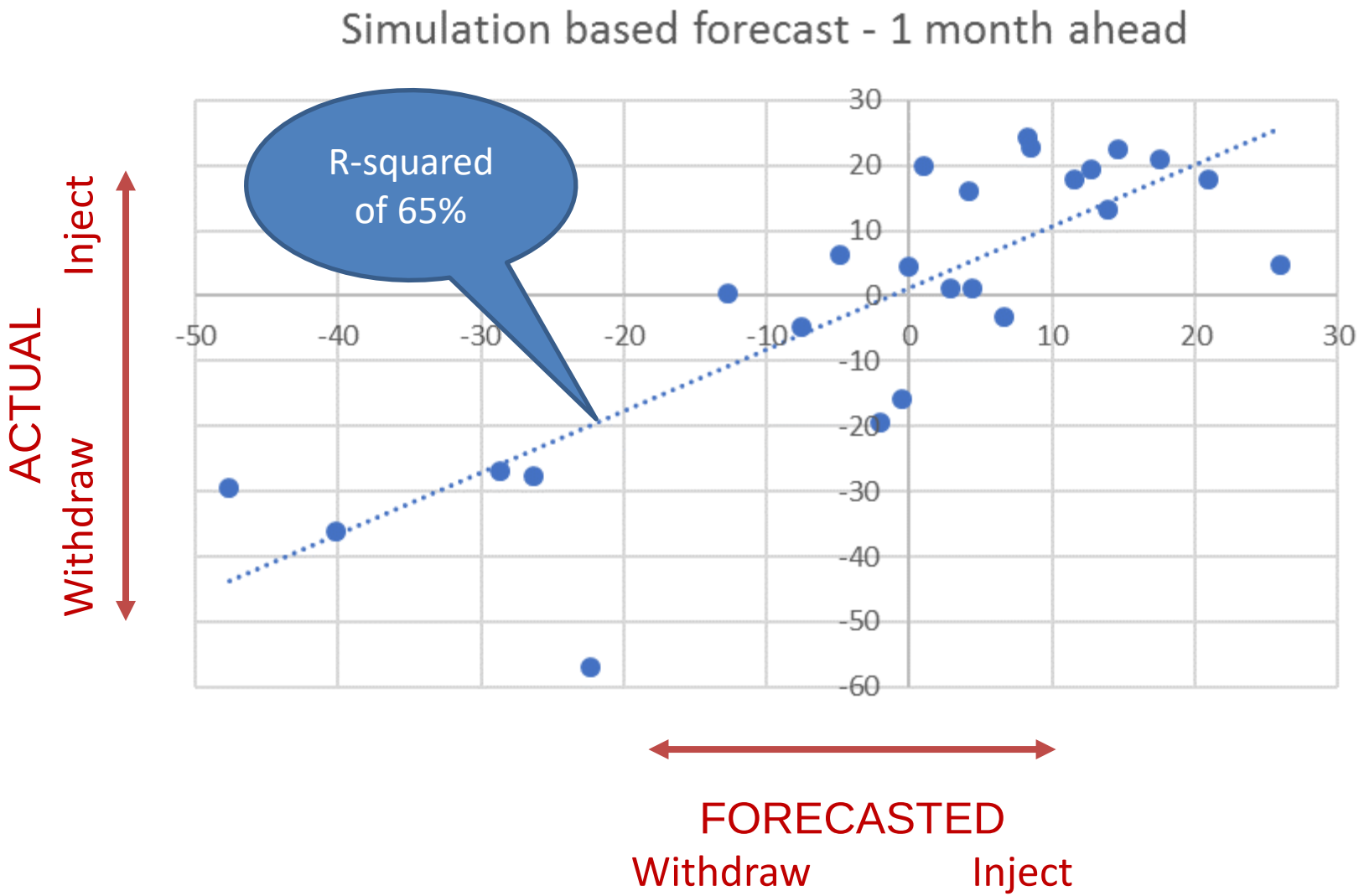
Apr-17: higher spot prices than expected (on 30 Mar 17)

Jan-17: higher spot prices than expected (on 30 Dec 16)



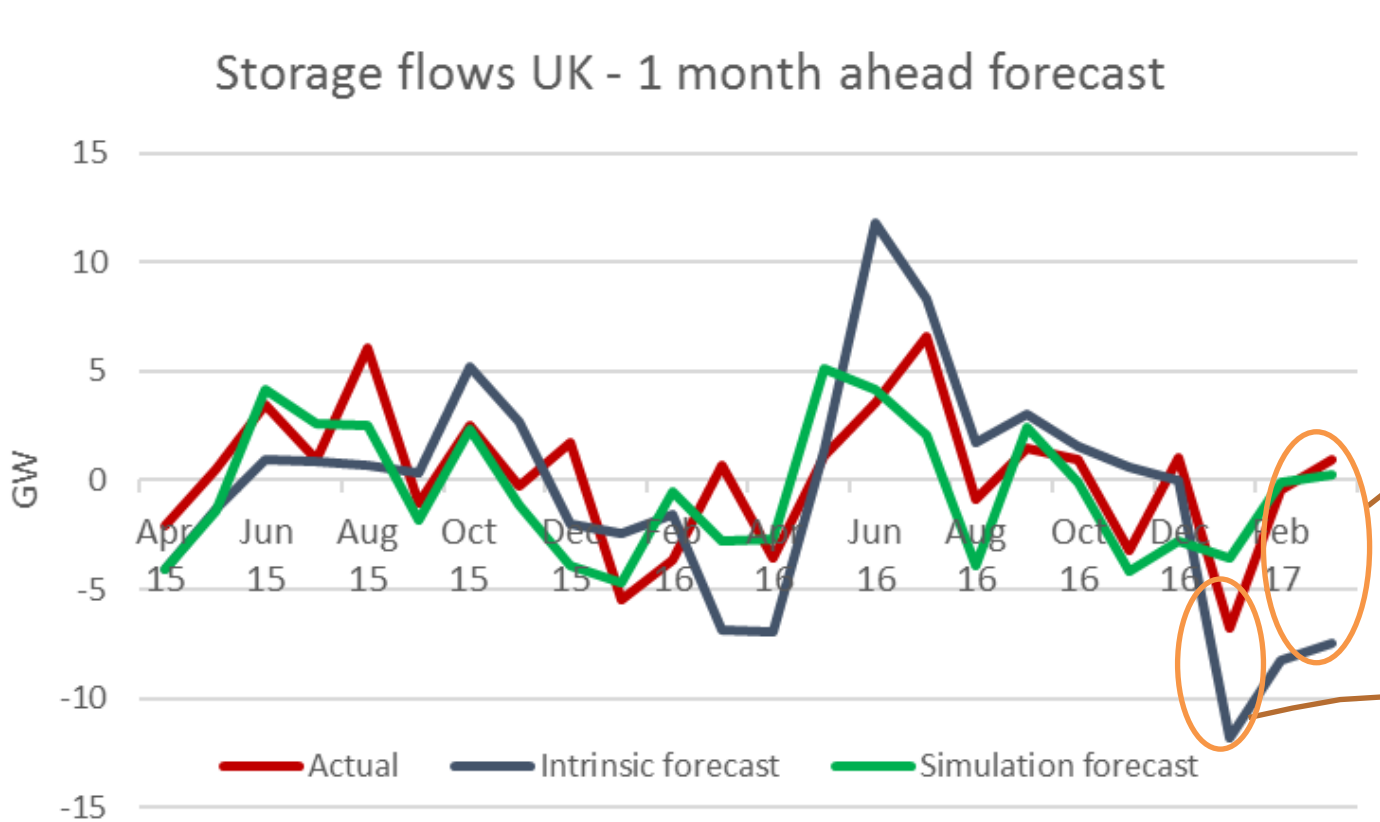
KYOS

Forecasting DE storage flows 1-month ahead



Forecasting UK storage flows 1-month ahead

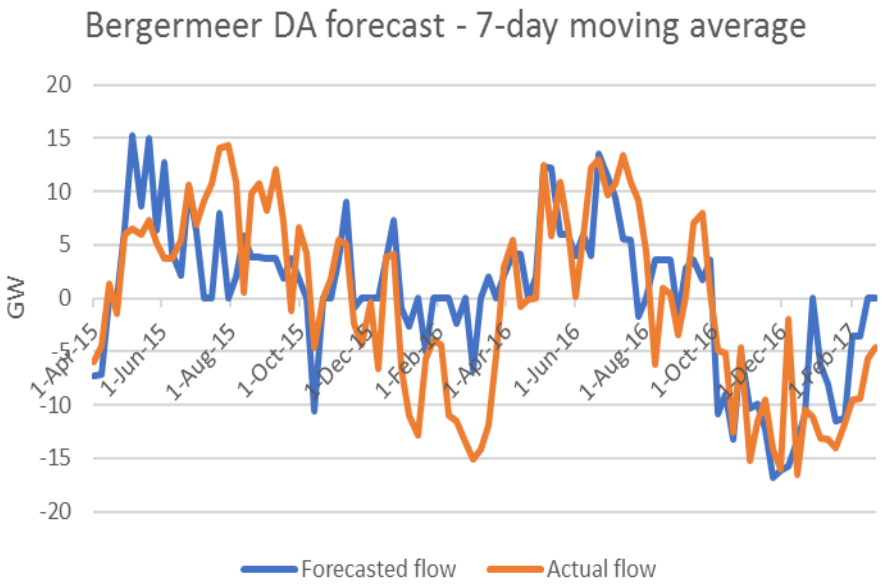
UK, excluding Rough:
Simulation based forecast 40% better than intrinsic forecast

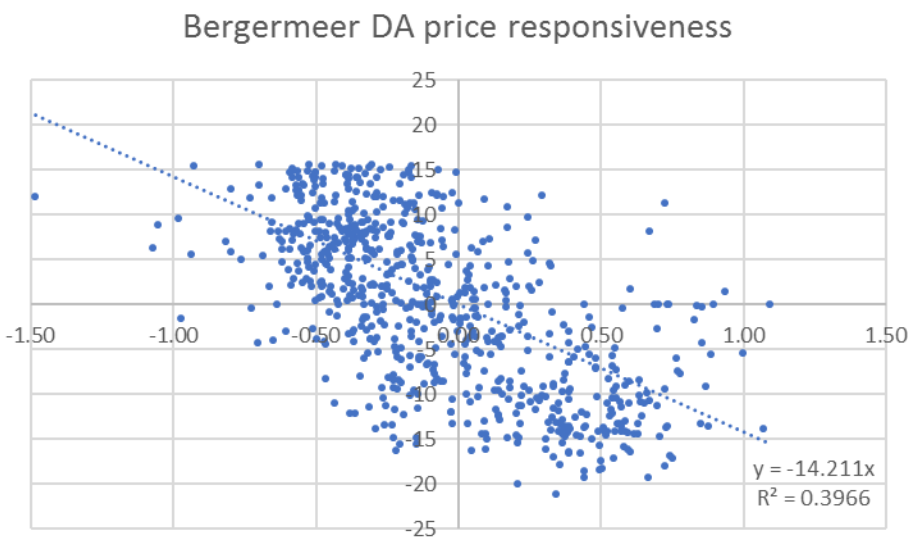


Mar-17: intrinsic suggests almost 100% release (on 28 Feb 17)

Jan-17: higher spot prices than expected (on 30 Dec 16)

Day-ahead volume forecast: Bergermeer (TTF)





Right graph:

- X-axis: price signal = spot price – “indifference price” (€/MWh)
- Y-axis: actual daily flow (GW)
- Hypothesis: high price differential leads to high withdrawal volume
- Regression results support hypothesis; 40% of daily flows explained by spot price (R-squared)

Conclusion

- Forecast of storage flows is key component of price forecast (time spreads)
- Storage models can help forecast storage flows
- Simulation approach (many price scenarios) works better than intrinsic approach (single scenario) to forecast storage flows
- Forecasting performance in UK and Germany is very similar