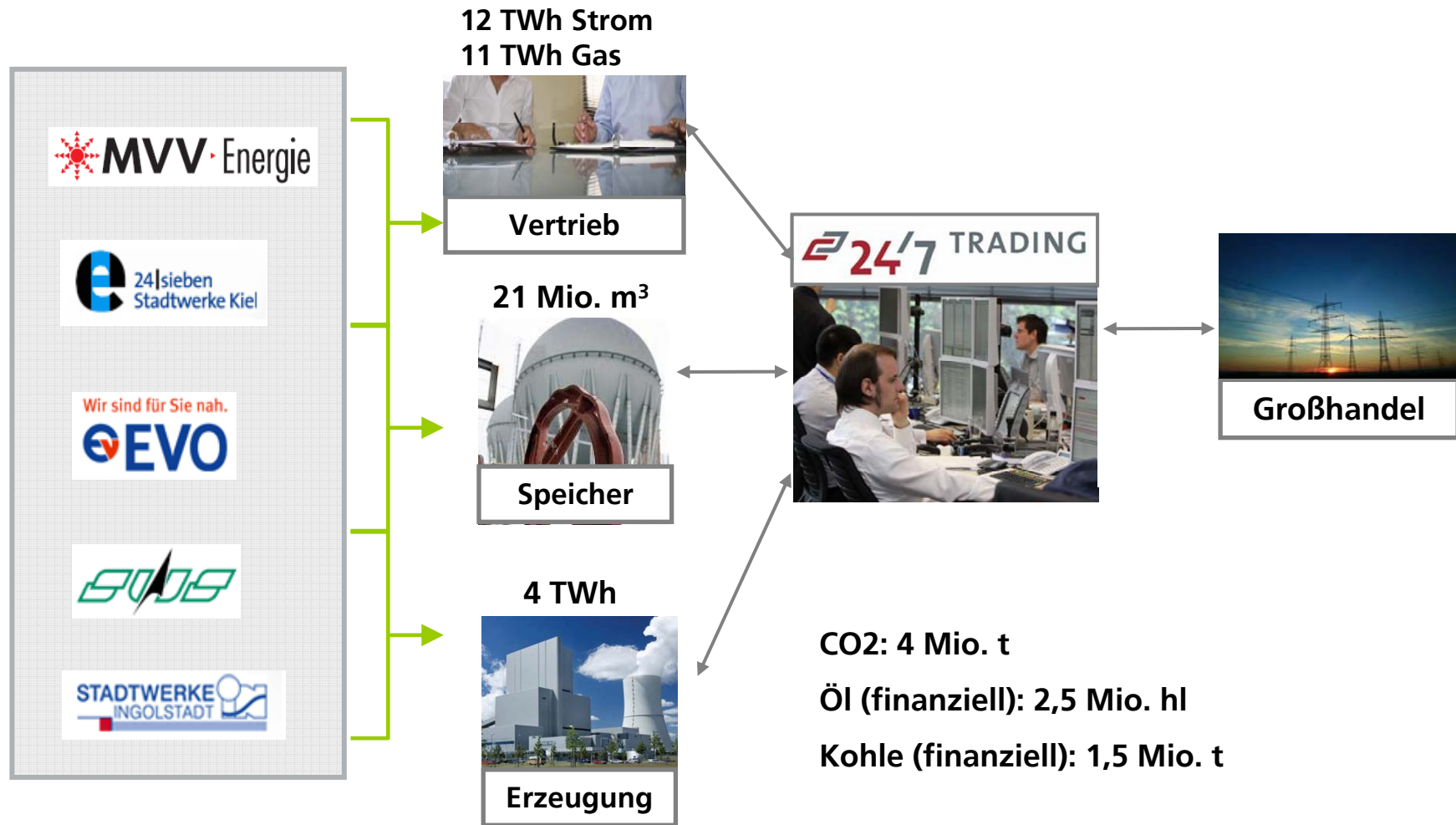


# Optimizing Gas Storage from a Trader's Perspective

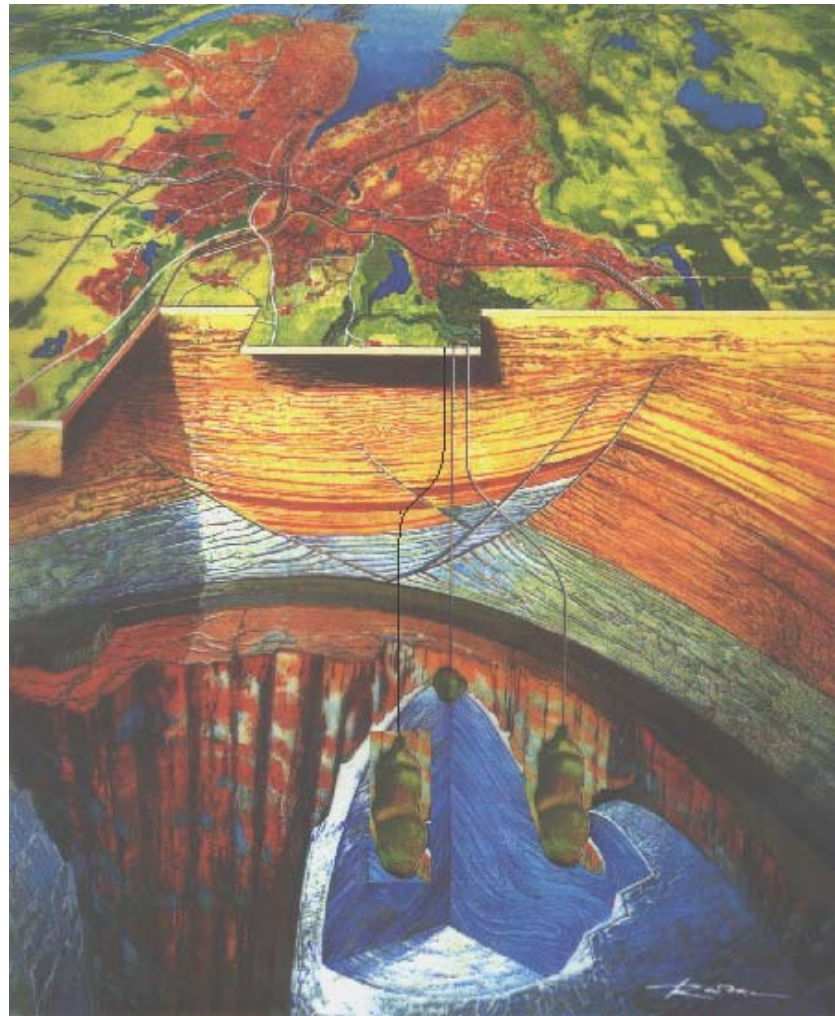
Volker Termath  
24/7 Trading



# gesamten Aktivitäten am Großhandelsmarkt über die 24/7 Trading



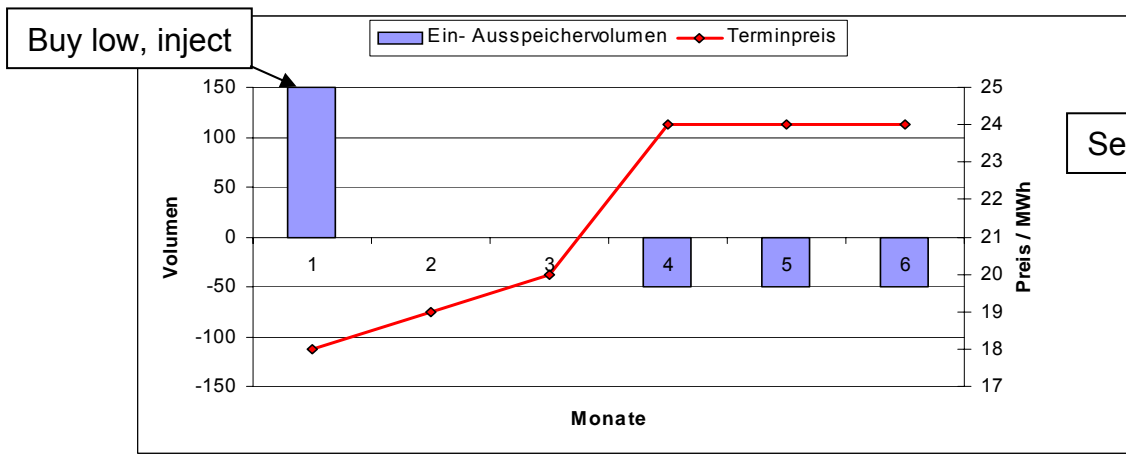
# MVV Group's Storage Facility at Kiel



# Agenda

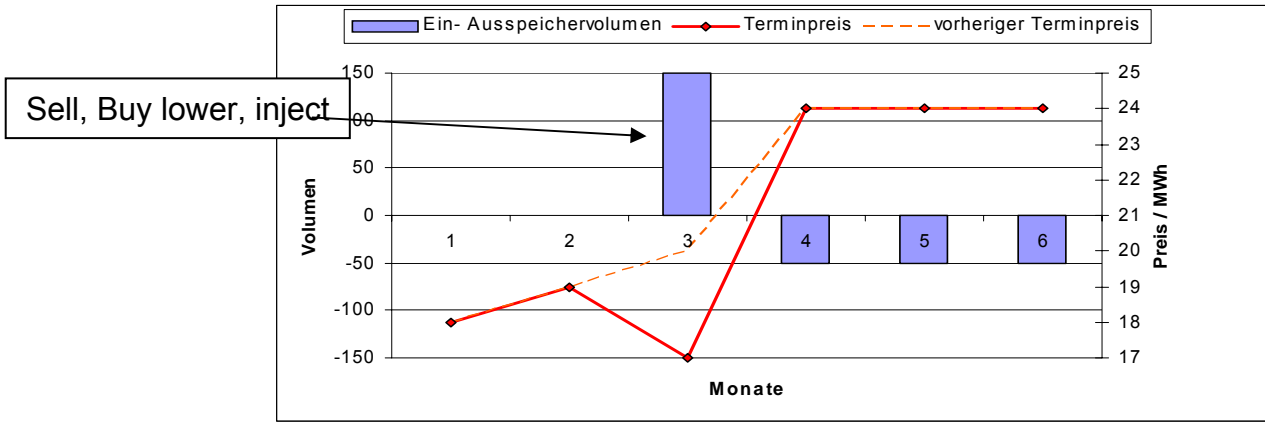
- ⇒ Valuing and Trading Storage
- ⇒ Basic ideas
- ⇒ Optimization
- ⇒ Forward Curve und Dynamics
- ⇒ Stochastic
- ⇒ Results vs. Market
- ⇒ Conclusions

# What Traders do: Arbitrage



Sell high, withdraw

Today's Forwardcurve and Hedge

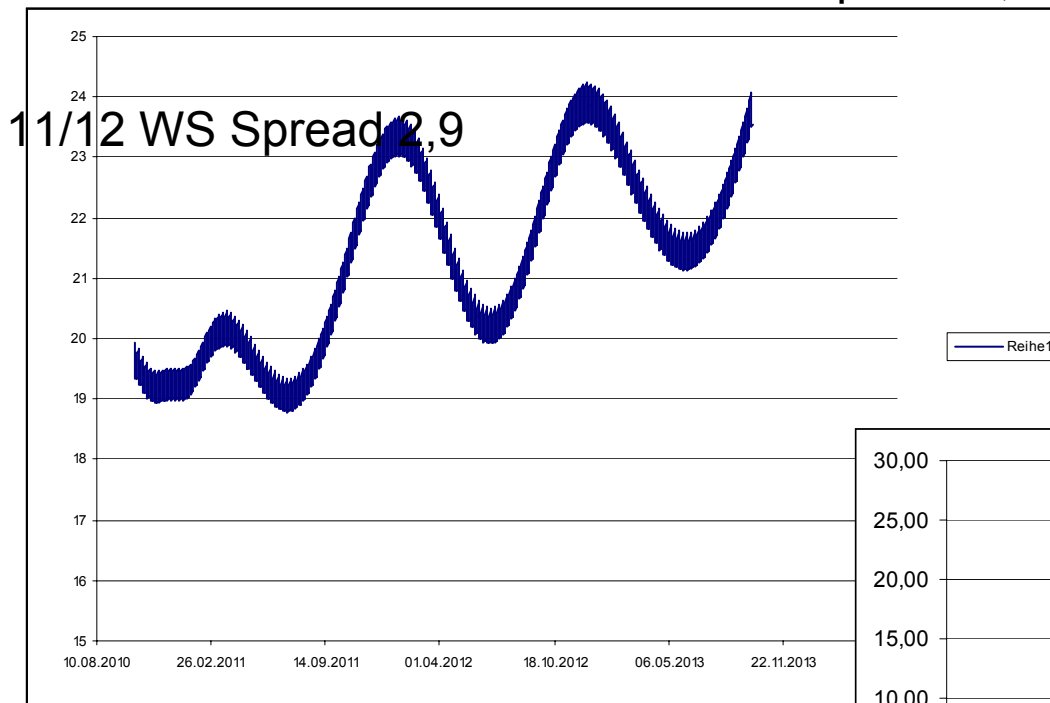


Tomorrow's Forward Curve and new Hedge; Profit: +150 Euro

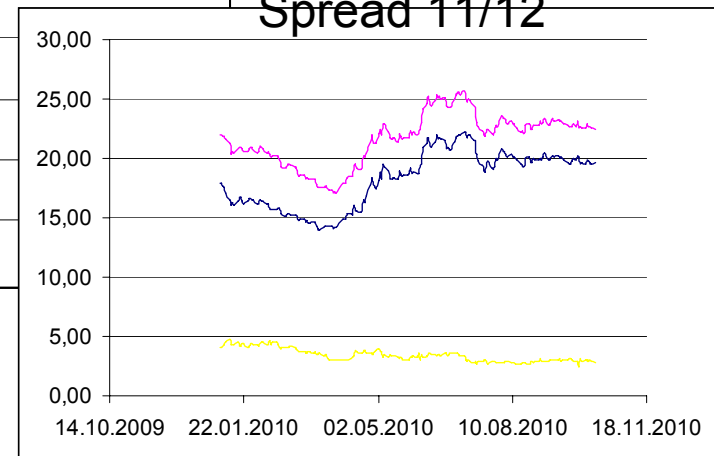
Rolling intrinsic Hedge

PFC 14.10.2010

12/13 WS Spread 2,3

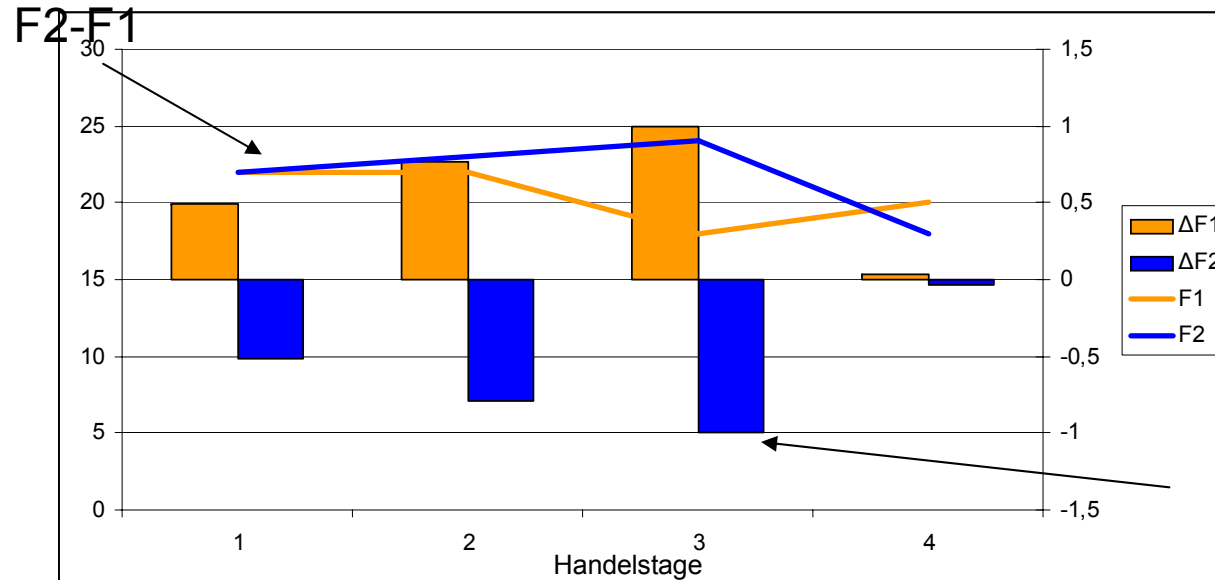


Spread 11/12



# Delta Hedge: value of time spread

Winter Summer Spread:

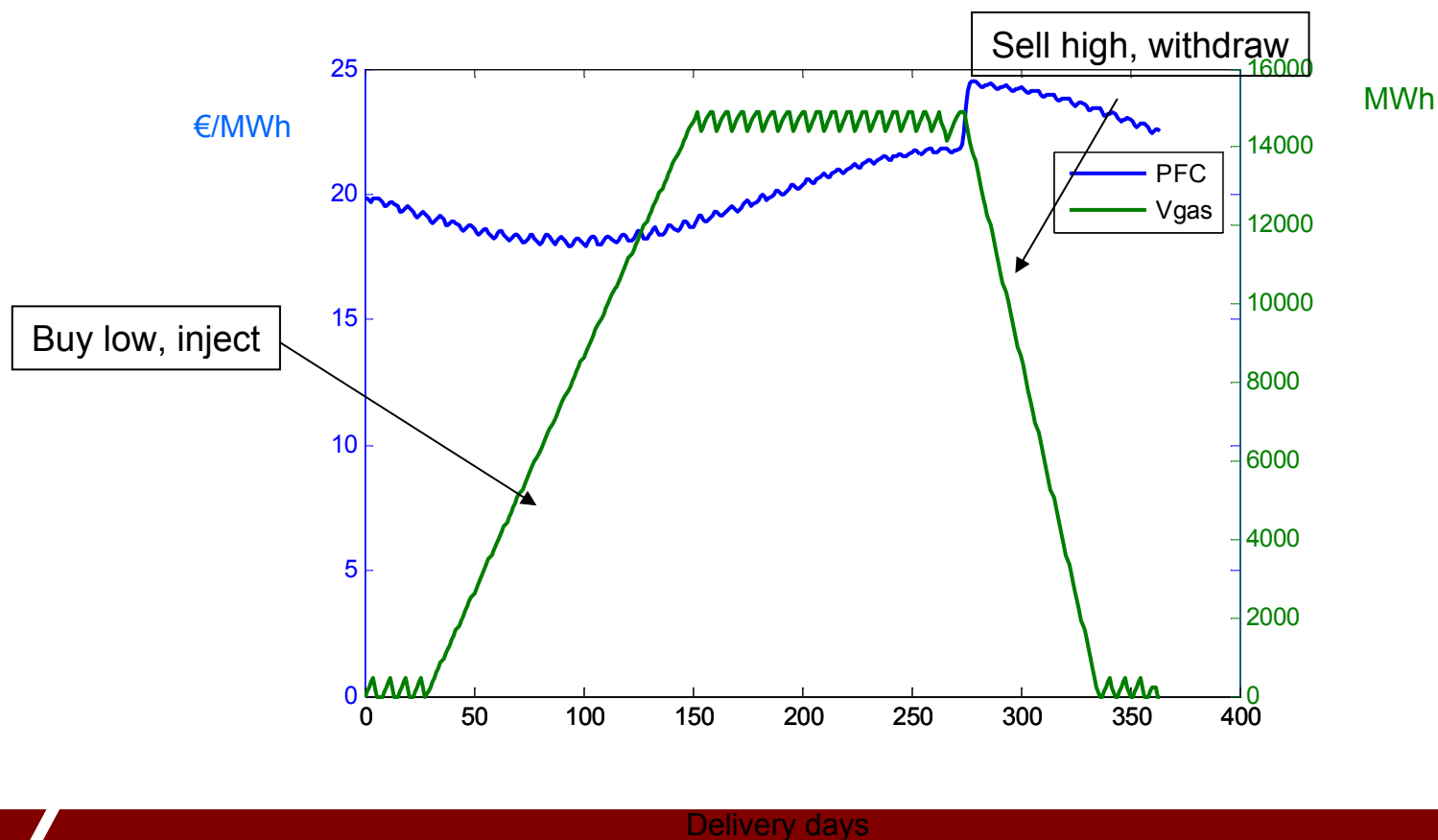


Delta Position:  
Inject-Wdraw :  
Hedge Forward curve

	Premium		Delta		MtM	Hedges
	F1	F2	C	ΔF1	ΔF2	
at the money	22	22	0,50665667	0,486921229	-0,513078771	0,575465946
In the money	22	23	1,164520796	0,769465366	-0,788886594	1,216153611
deep in the money	18	24	6,00000007	0,999999629	-0,999999737	6,00000036
out of the money	20	18	0,014680066	0,031562527	-0,036638288	0,028238652

# Do it like the traders do

- Storage trading: buy low, sell high against Gas PFC
- Do it on a daily basis
- Realize Cash Flow today
- Move on to tomorrow





# Algorithmics: Optimization



$$C(t, j) = \max_{k=\{\max(-j, -1); 0; \min(J-j, 2)\}} [C(t+1, j+k)e^{-r\Delta t} + (P(t) - \text{sign}(k) * bo) * v * k]$$

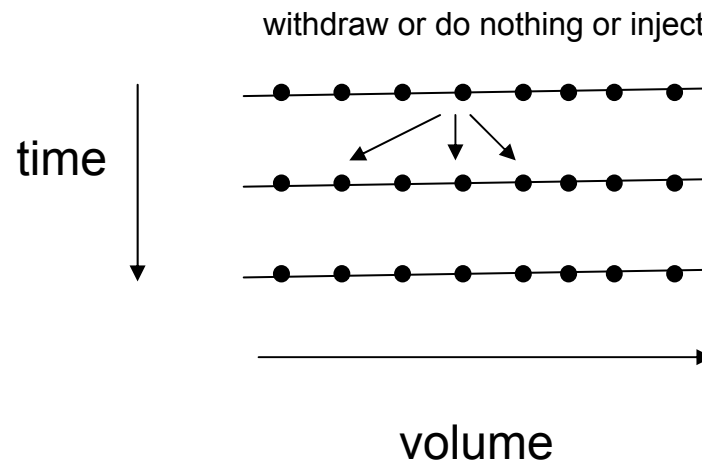
2D Grid:

•t: time 1...T

•j: volume 0 ...J\*v

P: price

bo: b/o spread



Initialisation:  $C(T+1, j) = 0$  or Penalty

# Theory: Curve Dynamics

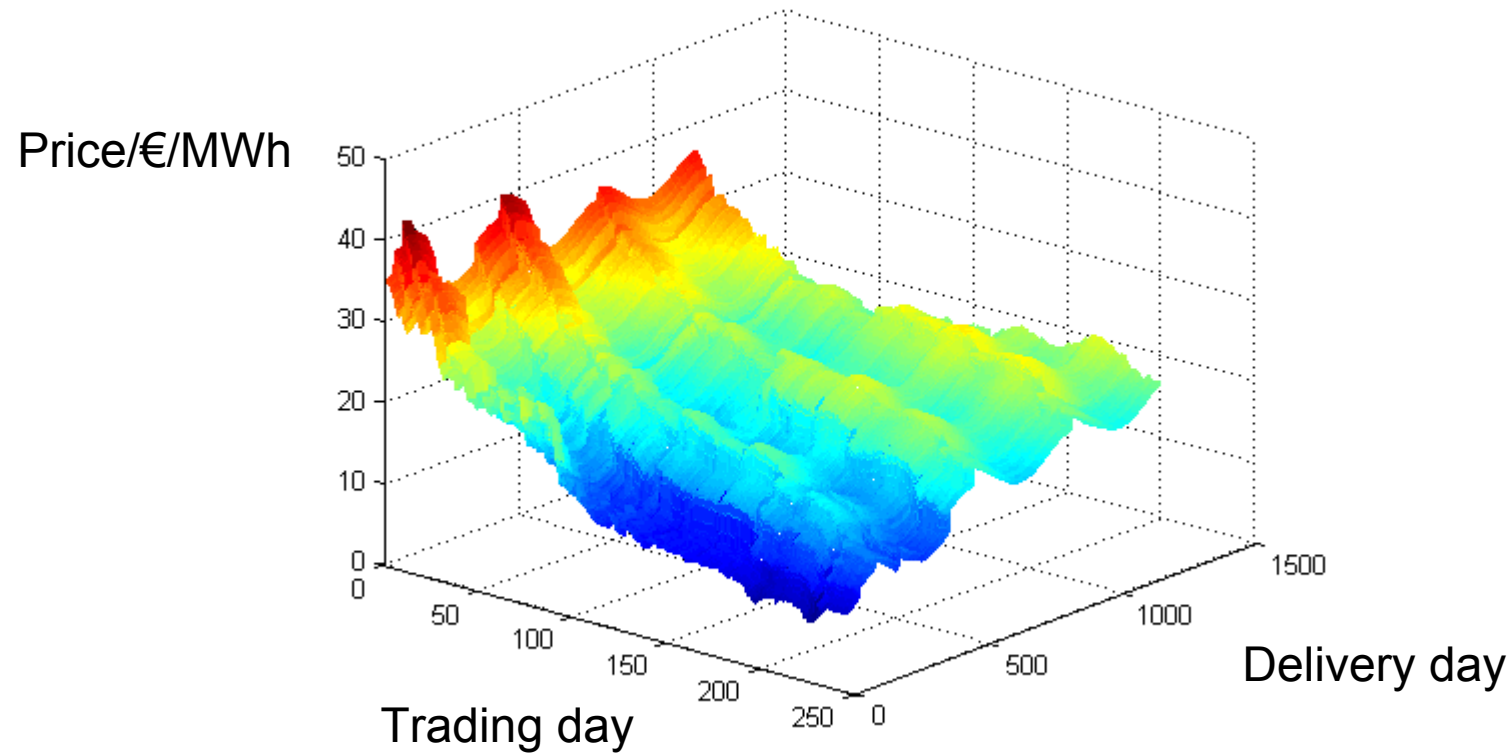
- ⇒ We choose uncorrelated, normal distributed Shocks  $dZ$  to model the return of the Forwardkurve  $F$

$$\frac{dF(t, T)}{F(t, T)} = \sum_{i=1}^N \sigma_i(t, T) dZ_i(t)$$

- ⇒ Shape and number of volatility functions  $\sigma$  are calculated based on a principal component analysis PCA
- ⇒ Propagation of the curve in time uses the integration scheme:

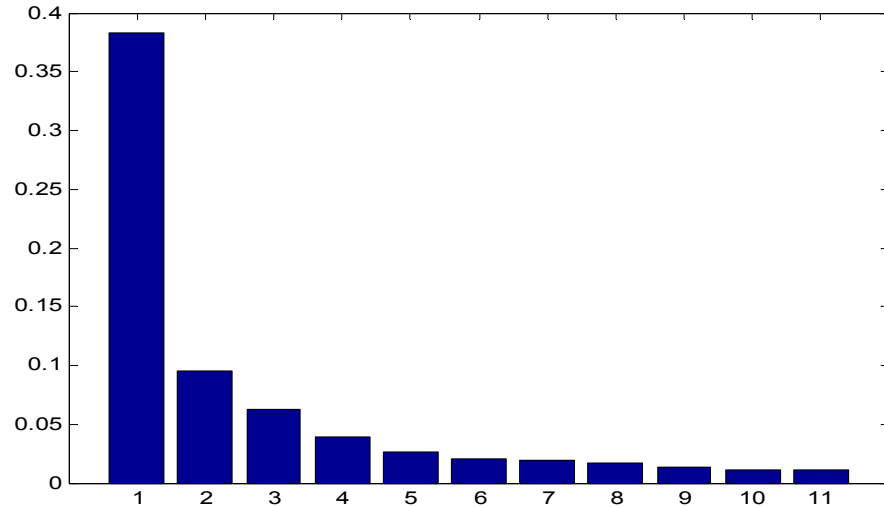
$$F(t + \Delta t, T) = F(t, T) \exp \left\{ \sum_{i=1}^N \left( \sigma_i(T - t) \sqrt{\Delta t} \cdot \tilde{\varepsilon}_i - \frac{1}{2} \sigma_i^2(T - t) \Delta t \right) \right\}$$

# PCA I: NCG Data



Plot of PFC along Gasyear 08/09 for NCG

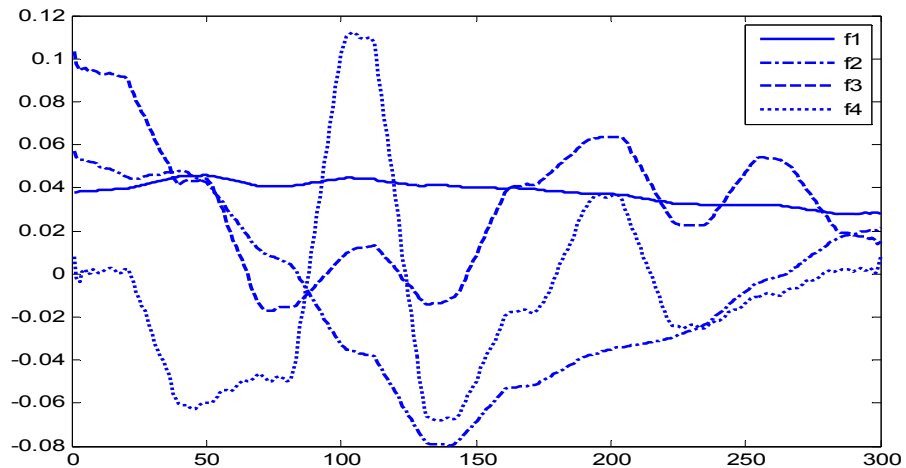
# PCA II: results



Weight of volatility function  $f_n$  in total expansion ( $f_1..f_5 > 80\%$ )

Interpretation of  $f_n$

- $f_1$ : parallel shift
- $f_2$ : bend
- $f_3$ : symmetric twist
- $f_4$ : asymmetric twist



# Rolling daily intrinsic Optimization

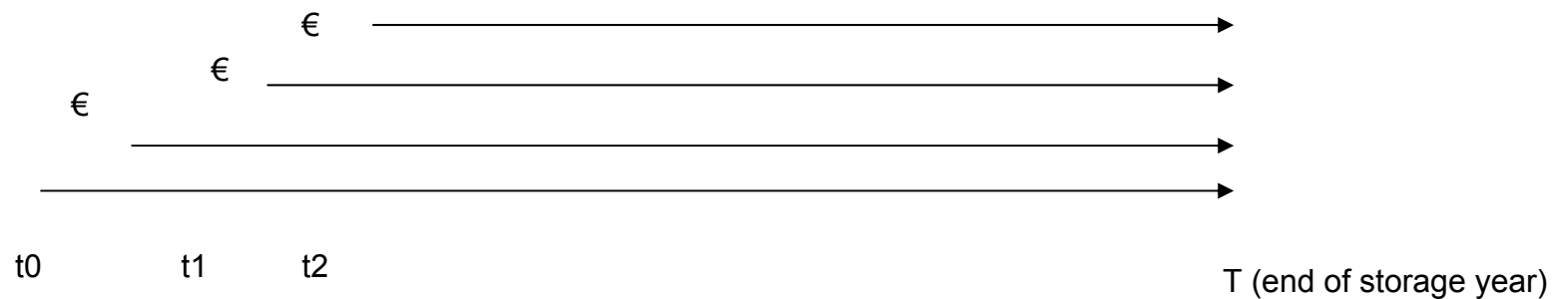
Decision at  $t$ :

- Inject
- Withdraw
- Do nothing

Realise optimal Cash Flow, discount, sum up

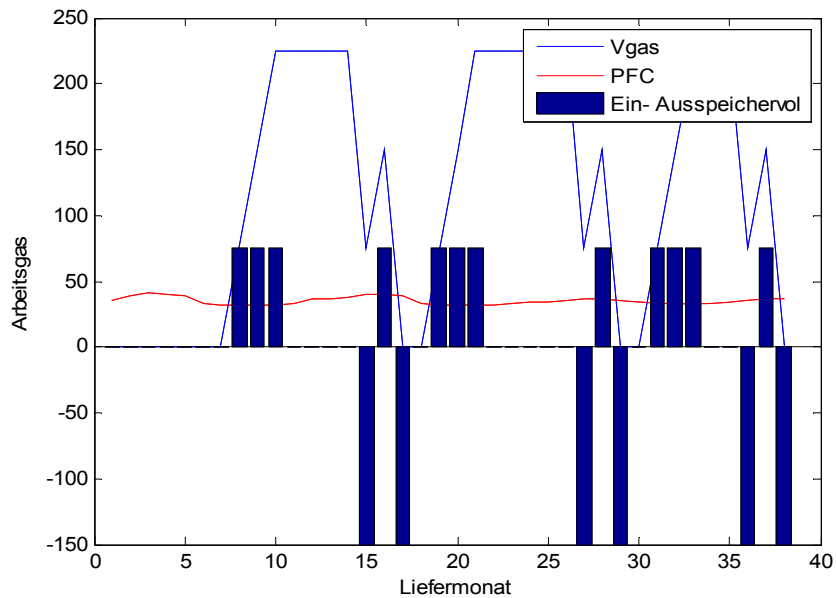
$t = t + 1$

propagate PFC

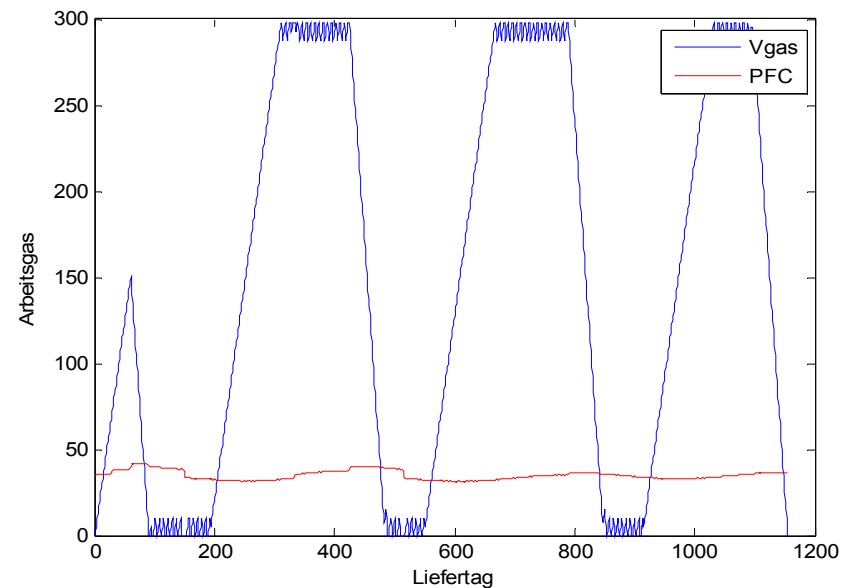


# Calculation I

- Intrinsic monthly against monthly PFC (static)
- Intrinsic, daily against PFC (static)
- SBU: 300 MWh working gas,  $V_{inj}$  1,25 MWh/d,  $V_{withdraw}$  2,5 MWh/d

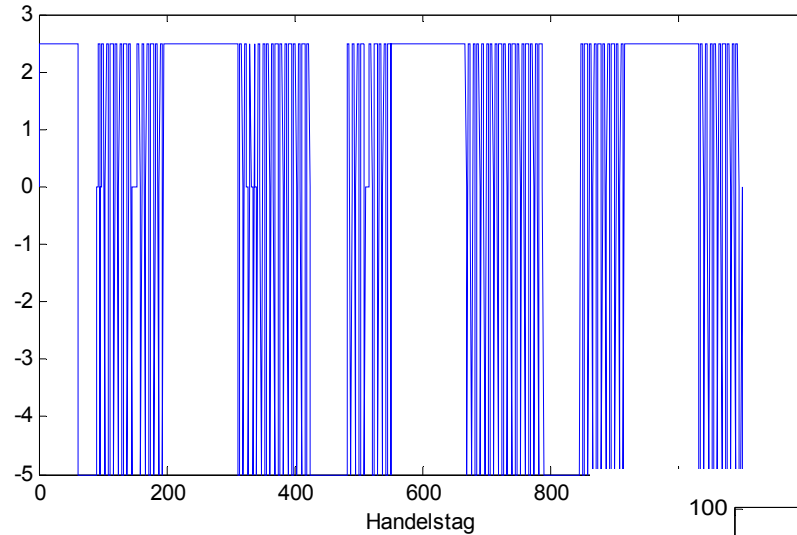


4,30 €/MWh WG/a

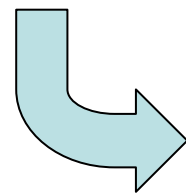


6,30 €/MWh WG/a

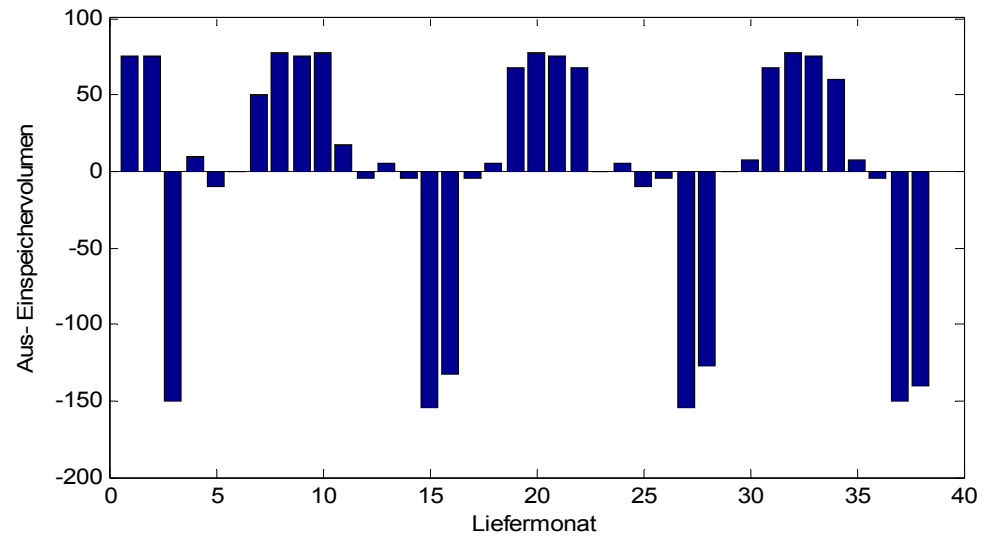
# Volumetric Hedge



Products



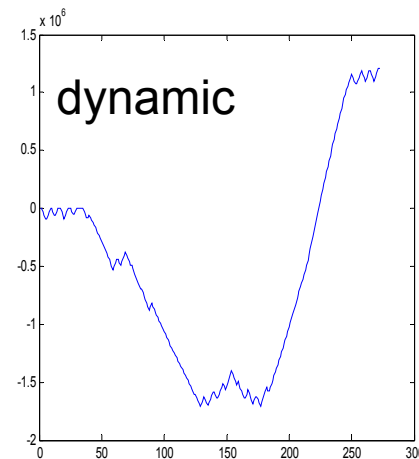
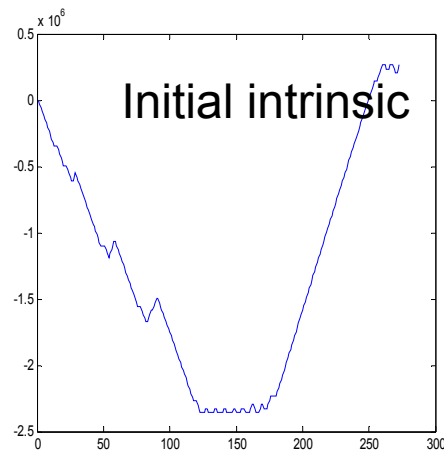
Cash Flow 5,75 €/MWh WG/a



# Calculation I

- ➔ Rolling intrinsic to the end of the storage year: 6,70 /MWh AG

cumulated Cashflows





## Monte Carlo

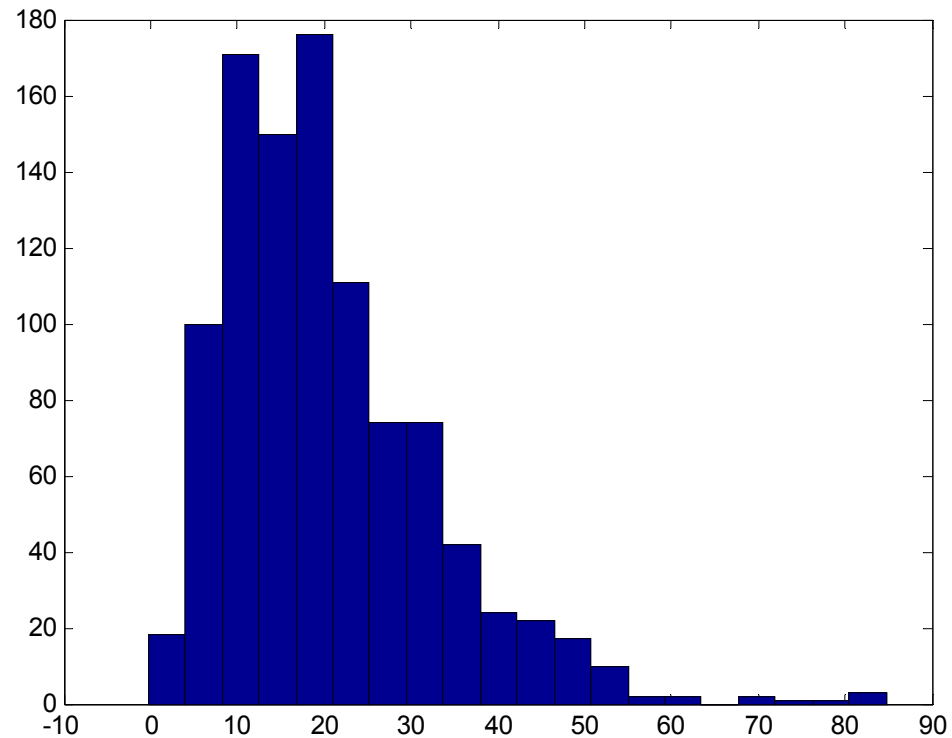
-> full time value: Monte Carlo with N runs of PFC propagation and rolling intrinsic hedging

## Implementation

Plain Matlab using

1. Vectorized expressions whenever possible
2. Matrix algebra wherever possible

# Monte Carlo

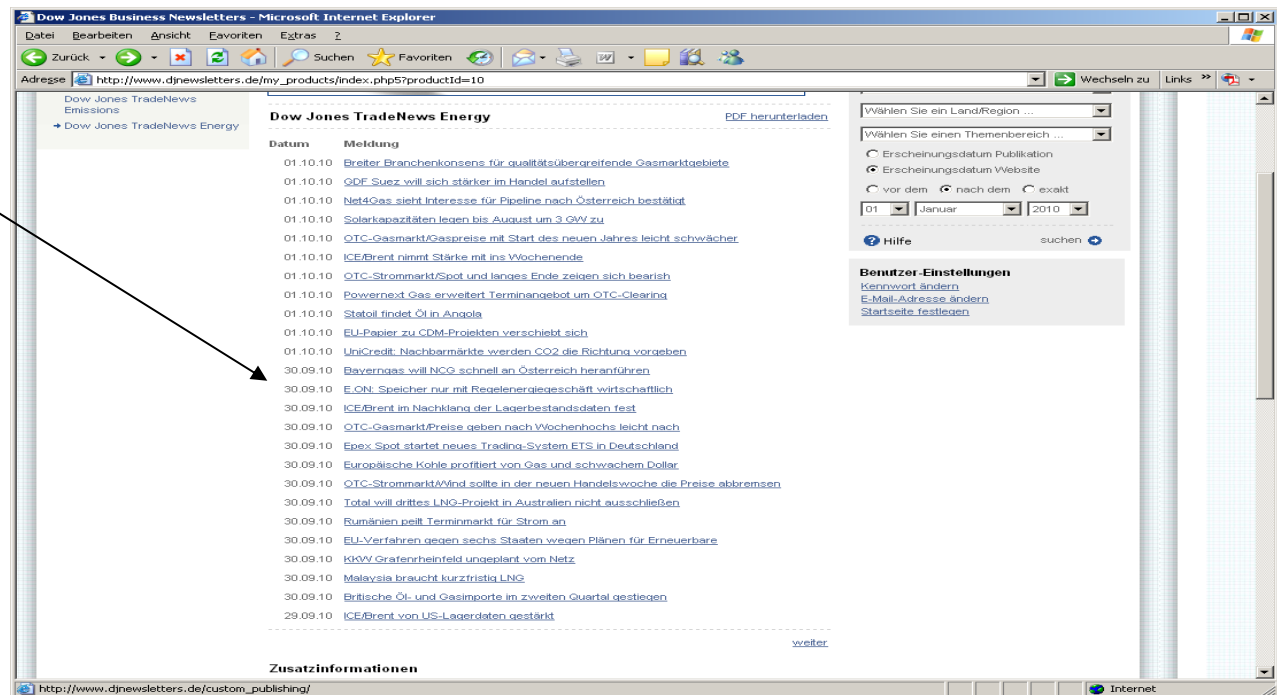


Pinj = 1.25 MW ,  
P wdrawal = 2.5 MW,  
WG 300 MWh  
PFC scaled to Gasyear 08/09

Runs: 10000, 7 s / intrinsic rolling Optimization for 1 year  
Value 12,7 €/MWh WG

# Conclusion

- ➔ Reasonable implementation
- ➔ Reasonable results compared to market
- ➔ Unreasonable German gas market who does not really cover storage costs



The screenshot shows the Dow Jones TradeNews Energy website in a Microsoft Internet Explorer browser window. The address bar displays the URL: [http://www.djnewsletters.de/my\\_products/index.php?productid=10](http://www.djnewsletters.de/my_products/index.php?productid=10). The page content is titled "Dow Jones TradeNews Energy" and features a list of news items with columns for "Datum" (Date) and "Meldung" (News). The news items are dated from 01.10.10 to 29.09.10. A black arrow points from the text "Unreasonable German gas market who does not really cover storage costs" to the news item dated 30.09.10: "E.ON: Speicher nur mit Regelenergiegeschäft wirtschaftlich". The right sidebar contains search filters and user settings. The bottom status bar shows the URL [http://www.djnewsletters.de/custom\\_publishing/](http://www.djnewsletters.de/custom_publishing/) and the "Internet" icon.

Datum	Meldung
01.10.10	<a href="#">Breiter Branchenkonsens für qualitätsübergreifende Gasmarktgebiete</a>
01.10.10	<a href="#">QDF Suez will sich stärker im Handel aufstellen</a>
01.10.10	<a href="#">Net4Gas sieht Interesse für Pipeline nach Österreich bestätigt</a>
01.10.10	<a href="#">Solarkapazitäten legen bis August um 3 GW zu</a>
01.10.10	<a href="#">OTC-Gasmarkt/Gaspreise mit Start des neuen Jahres leicht schwächer</a>
01.10.10	<a href="#">ICE/Brent nimmt Stärke mit ins Wochenende</a>
01.10.10	<a href="#">OTC-Strommarkt/Spot und langes Ende zeigen sich bearish</a>
01.10.10	<a href="#">Powernext Gas erweitert Terminangebot um OTC-Clearing</a>
01.10.10	<a href="#">Stetoll findet Öl in Angola</a>
01.10.10	<a href="#">EU-Papier zu CDM-Projekten verschiebt sich</a>
01.10.10	<a href="#">UniCredit: Nachbarmärkte werden CO2 die Richtung vorgeben</a>
30.09.10	<a href="#">BavariaGas will NCG schnell an Österreich heranzuführen</a>
30.09.10	<a href="#">E.ON: Speicher nur mit Regelenergiegeschäft wirtschaftlich</a>
30.09.10	<a href="#">ICE/Brent im Nachklang der Lagerbestandsdaten fest</a>
30.09.10	<a href="#">OTC-Gasmarkt/Preise geben nach Wochenhochs leicht nach</a>
30.09.10	<a href="#">EpeX Spot startet neues Trading-System ETS in Deutschland</a>
30.09.10	<a href="#">Europäische Kohle profitiert von Gas und schwachem Dollar</a>
30.09.10	<a href="#">OTC-Strommarkt/Wind sollte in der neuen Handelswoche die Preise abbremsen</a>
30.09.10	<a href="#">Total will drittes LNG-Projekt in Australien nicht ausschließen</a>
30.09.10	<a href="#">Rumänien peilt Terminmarkt für Strom an</a>
30.09.10	<a href="#">EU-Verfahren gegen sechs Staaten wegen Plänen für Erneuerbare</a>
30.09.10	<a href="#">KdV Grafenheinfeld ungeplant vom Netz</a>
30.09.10	<a href="#">Malaysia braucht kurzfristig LNG</a>
30.09.10	<a href="#">Britische Öl- und Gasimporte im zweiten Quartal gestiegen</a>
29.09.10	<a href="#">ICE/Brent von US-Lagerdaten gestärkt</a>

# Acknowledgements



- ➔ Dr. Christian Mühlinghaus for his famous Market Data warehouse
- ➔ Dr. Michael Redanz for his interest in and patience with my research in gas storage science

Thank you for your attention