Relevance of Risk Capital and Margining for the Valuation of Power Plants: Cash Requirements for Credit Risk Mitigation

5th Conference on Energy Economics and Technology
(ENERDAY 2010)

Dresden, April 16th, 2010
Outline

1. Background / Motivation
2. Research questions
3. Methodological approach
4. Results
5. Conclusions
A special issue with regard to the valuation of power plants is the recognition of risk capital …

- Electricity is still mostly sold via bilateral contracts in so-called “over-the-counter” (OTC) trades as well as in the form of long-term delivery contracts.

- These contracts normally only partly include credit risk mitigation instruments.

- However, strong increase in the collateralization of OTC trades in addition to the trades on the exchange is noticeable [1].

- Institutions like the European Commission are calling for a stronger general control of derivatives using centralized clearing to enforce a better control and prohibit arbitrage on regulatory regimes [2].
Fundamentals of margining – What are margins?

A Margin is “a collateral posted with the future exchanges clearing company by an outside counterparty to ensure the eventual performance” [3, p.1206].

This collateral may be adjusted by a so-called “margin call” of the Clearing Company to the respective trading entities (Seller and Buyer) if the collateral of the underlying trading position is not enough to cover the value of its mark-to-market value.

“In this context each open futures position is re-evaluated on a daily basis until the last day of trading. At that time, profits and losses are settled in cash and credited to the Clearing Member or debited with said party as variation margin. By means of the conclusion of a futures transaction both parties, the buyer and seller, enter into an obligation for the daily payment of additional calls regarding the variation margin” [4, p.7].
The risk capital resulting from the need for margining is relevant for the value of a power plant …

- In the case that market risks are covered by hedges, credit risks and, as a consequence of collateralization, margin requirements occur.
- One can interpret the total expected risk capital for margining as additional investment with repayment character at the end of the trading period, which has to be ensured to be available for the potential margin calls.
- Risk capital position has to be built up with the commissioning of the plant and will decrease / be zero at the end of the delivery period (e.g. end of lifetime) and the close-out of all open positions (comparable to a coal stock of a power plant).
- Required liquidity for margining has therefore the character of “working capital”, which is constantly needed for the trading of fuel, CO₂ certificates, and electricity output for a specific power plant or portfolio.
- This view is supported by the German accounting principles (HGB) for which the Variation Margin has to be booked as “deposits received” or “deposits paid” (see [8], p.220) and thus, is part of the Working Capital (see [9], p.205f).

**Margining should be recognized in the valuation of a power plant, as working capital movements are included in the calculation of the free cash flow** (e.g. [10], p.320).
2. Research questions

...leading to further questions with regard to the valuation of power plants

- Which effects does the mitigation of credit risks on power exchanges via margining have on the cashflow of power plants?

- What are the major influencing factors on the total margin and what is the risk capital required (so-called “Economic Capital”)?

- What are the impacts of the different fuel types and hedging strategies on the margining amounts?

Underlying set-up / procedure for analysis

- Time-series analysis of the margin requirements in €/MW for 1 MW of capacity for coal- and gas-fired power plant (spread-based) and 1 MW of outright power (only electricity sales).

- Margining requirements as stated by the European Commodity Clearing AG (ECC).

- Time horizon: Delivery years 2009 and 2010; 2-years-ahead commercialization using futures for electricity, coal, gas and CO\textsubscript{2} traded at the EEX
3. Methodological approach

For trades at the EEX a set of different margins for Futures and Options applies

Besides the Variation Margin (obligatory for any open position) the following margins apply for Options and Futures

<table>
<thead>
<tr>
<th>Open positions in</th>
<th>Premium Margin</th>
<th>Additional Margin</th>
<th>Spread Margin</th>
<th>Initial Margin</th>
<th>Delivery Margin</th>
<th>Intra-Day Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power options</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Options on emission rights</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Power futures</td>
<td></td>
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<td>X</td>
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<tr>
<td>Natural gas futures</td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Coal futures</td>
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<td>X</td>
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<tr>
<td>Emission Futures</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Source: [4, p.10]. For open positions for supply obligations and obligations to take delivery (gas and CO₂ Futures) the Delivery Margin and for trades in the spot market the Initial Margin is necessary.

Relevant for this analysis + Variation Margin
3. Methodological approach

The first step in our analysis was the determination of the respective generation volume for each of the power plants...

**Input:** Sources: EEX, own assumptions, [5, p.293]

- Hour-by-hour-analysis (8760h) of dispatch expectation by binary decision by comparing the Electricity Spot Price vs. the Marginal Costs. For 2010: Average p. hour of 2007-2009
- State-of-the-art power plants: Efficiency: Coal 46%, CCGT 56%, less 2% to cover start-up losses, availability assumptions: Coal 90%, CCGT 90%, Outright power 90% (e.g. nuclear or run-of-river)
- Electricity prices: Germany Spot prices 2007-2009, hour-by-hour
- Coal prices: API#2 cif ARA, Monthly Futures 2007-2009, daily notations, weekend prices = last price of last trading day before
- Gas prices: NCG & TTF Spot prices 2007-2009, daily notations, weekend prices = last trading day before the weekend/holiday
- CO2 prices: Spot prices 2007-2009, daily notations for Germany
- Additional other variable costs assumed: Coal: 2.5 €/MWh$_{el}$, Gas: 1€/MWh$_{el}$

**Output:**

- Total amount of hours dispatched in corresponding year on a daily basis
- Distribution of peak hours vs. off-peak hours
3. Methodological approach

...followed by the development of deterministic hedging strategies for the impact analysis

### Hedged product

<table>
<thead>
<tr>
<th></th>
<th>Linear hedging function</th>
<th>Square root hedging function</th>
<th>Quadratic hedging function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Off-peak hours</strong></td>
<td>$h_{i,s}^{\text{base}} = \left( \sum_{t=1}^{T} v_{it} \right) \cdot \frac{1}{S} \cdot \alpha_b$</td>
<td>$h_{i,s}^{\text{base}} = \sum_{t=1}^{T} v_{it} \cdot \sqrt{\frac{S}{S}} \cdot \alpha_b - h_{i,s-1}^{\text{base}}$</td>
<td>$h_{i,s}^{\text{base}} = \sum_{t=1}^{T} v_{it} \cdot \left( \frac{S}{S} \right)^{2} \cdot \alpha_b - h_{i,s-1}^{\text{base}}$</td>
</tr>
<tr>
<td><strong>Peak hours</strong></td>
<td>$h_{i,s}^{\text{peak}} = \left( \sum_{t=1}^{T} v_{it} \right) \cdot \frac{1}{S} \cdot \alpha_p$</td>
<td>$h_{i,s}^{\text{peak}} = \sum_{t=1}^{T} v_{it} \cdot \sqrt{\frac{S}{S}} \cdot \alpha_p - h_{i,s-1}^{\text{peak}}$</td>
<td>$h_{i,s}^{\text{peak}} = \sum_{t=1}^{T} v_{it} \cdot \left( \frac{S}{S} \right)^{2} \cdot \alpha_p - h_{i,s-1}^{\text{peak}}$</td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td>$h_{i,s}^{\text{Coal}} = \left( h_{i,s}^{\text{base}} + h_{i,s}^{\text{peak}} \right) / \eta^{\text{coal}} \cdot k^{\text{coal}}$</td>
<td></td>
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<tr>
<td><strong>Gas</strong></td>
<td>$h_{i,s}^{\text{gas}} = \left( h_{i,s}^{\text{base}} + h_{i,s}^{\text{peak}} \right) / \eta^{\text{gas}}$</td>
<td></td>
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<tr>
<td><strong>CO₂</strong></td>
<td>$h_{i,s}^{\text{CO₂}} = \left( h_{i,s}^{\text{base}} + h_{i,s}^{\text{peak}} \right) \cdot ef^{\text{Fuel}} / \eta^{\text{powerplan}}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Start of delivery year,
100% hedged at this point for 2009

![Graph showing hedging functions](image)
3. Methodological approach

For the calculation of the margins, we applied the margining requirements of the ECC AG *

Calculation: **Variation Margin**

- Daily calculation on open position for each product.
- The change of the Variation Margin \( \text{VM}_i(s) \) of a certain product \( i \) at a day \( s \) can be calculated by multiplying the cumulated hedged volumes of the product of the last day with the daily settlement price change:

\[
\text{VM}_i(s) = \left( \sum_{s=1}^{s-1} v_{it} \right) \cdot \left( p_{i,s-1} - p_{i,s} \right)
\]

- Short positions (electricity) and long positions (fuels, CO2) had been netted

Calculation: **Additional Margin**

- Daily calculation on relevant increase / decrease of net position.

\[
\text{AM}_s = \sum_{i=1}^{n} \sum_{s=1}^{S} \left( n_{p_is} \cdot c_{v_i} \cdot \text{AMP}_{is} \cdot \text{EMF}_{is} \right)
\]

- \( n_{p_is} \) ... net position of a certain product \( i \) at a certain time \( s \)
- \( c_{v_i} \) ... standard contract volume (we assume \( c_{v_i} = 1 \))
- \( \text{AMP}_{is} \) ... additional margin parameter
- \( \text{EMF}_{is} \) ... expiry month factor

Mark-to-market valuation of the existing positions to cover risks from price changes.

Coverage of possible additional close-out losses from open positions in case those have to be closed out on the next trading day at possibly worse prices.

* Source: [4]. With regard to some calculations, like e.g. the cascading in the delivery year, simplifications were used. Spread margin not relevant for our study as we only had long positions for CO2.
4. Results

We analyzed our results for the respective margins in a two-dimensional framework...

* Besides the three named strategies here, we further analysed hedging scenarios in a best- and worst case scenario.
4. Results

...using time series of the margins for all power plants and the applied hedging strategies for the period 2007-2009

VM & AM for Futures contracts with delivery year 2009/2010 –
linear hedging function, coal-fired power plant

2009 & 2010

Applied hedging strategy:
constant linear hedge over 2 years with daily trades

Elec. product composition for hedge

2009
Peak 48.8%
Base 51.2%

2010
Peak 49.5%
Base 50.5%

Coal-fired

negative value: margin to be paid
positive value: margin payment received

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume coal
In the analysis of the Variation Margins, we found some significant differences between the fuel types …

<table>
<thead>
<tr>
<th>Analysis on Variation Margin requirements: Maximum value in 1000 €/MW</th>
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</thead>
<tbody>
<tr>
<td>Linear hedging function</td>
</tr>
<tr>
<td>Coal-fired</td>
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<tr>
<td>VM Elec.</td>
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<tr>
<td>VM Fuel</td>
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<td>VM CO2</td>
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<tr>
<td>VM Total</td>
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<tr>
<td>VM Elec.</td>
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<td>VM Fuel</td>
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<td>VM CO2</td>
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<tr>
<td>VM Total</td>
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<tr>
<td>VM Elec.</td>
</tr>
<tr>
<td>VM Fuel</td>
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<tr>
<td>VM CO2</td>
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<tr>
<td>VM Total</td>
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</table>

<table>
<thead>
<tr>
<th>Gas-fired</th>
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</thead>
<tbody>
<tr>
<td>VM Elec.</td>
</tr>
<tr>
<td>VM Fuel</td>
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<tr>
<td>VM CO2</td>
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<tr>
<td>VM Total</td>
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<tr>
<td>VM Elec.</td>
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<tr>
<td>VM Fuel</td>
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<tr>
<td>VM CO2</td>
</tr>
<tr>
<td>VM Total</td>
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<tr>
<td>VM Elec.</td>
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<tr>
<td>VM Fuel</td>
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<td>VM CO2</td>
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<tr>
<td>VM Total</td>
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<thead>
<tr>
<th>Outright power</th>
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</thead>
<tbody>
<tr>
<td>VM Elec.</td>
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<tr>
<td>VM Fuel</td>
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<tr>
<td>VM CO2</td>
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<tr>
<td>VM Total</td>
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<tr>
<td>VM Elec.</td>
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<tr>
<td>VM Fuel</td>
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<tr>
<td>VM CO2</td>
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<tr>
<td>VM Total</td>
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<tr>
<td>VM Elec.</td>
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<tr>
<td>VM Fuel</td>
</tr>
<tr>
<td>VM CO2</td>
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<tr>
<td>VM Total</td>
</tr>
</tbody>
</table>

Significant higher VM_{Fuel} for the CCGT was not directly explainable with higher volumes like for the VM_{Elec} or VM_{CO2}

All values in 1000 €/MW. Margins can not be added and have to be seen independently as they represent maximum values of the separate margins over the time horizon of hedging. Negative sign: Margin to be paid, positive sign: Margin payment to be received.
**4. Results**

With regard to the differences in the VM needs for electricity and CO\(_2\), the explanation is given by the differences in the volumes.

Higher efficiency and lower CO\(_2\) Emission per MWh of fuel (0.2 vs. 0.34 t/MWh) leads to significantly lower CO\(_2\) volumes and thus lower margin needs.

Lower margin needs for VM\(_{\text{Elec}}\) are driven by lower generation volumes of the different fuel types (as for all generation types the same prices apply).

### Table: Hourly Calculation of CO\(_2\) Need

<table>
<thead>
<tr>
<th>Year</th>
<th>Total hours p.a.</th>
<th>Thereof peakload hours</th>
<th>Thereof off-peak hours</th>
<th>Total hours p.a. (availability adjusted)</th>
<th>Assumed coal consumption in t</th>
<th>Assumed gas consumption in MWh (HHV)</th>
<th>Assumed CO(_2) need in t</th>
</tr>
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<tbody>
<tr>
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<tr>
<td><strong>Gas-fired power plant</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>5,291</td>
<td>2,924</td>
<td>2,367</td>
<td>4,762</td>
<td>9,766</td>
<td>1,781</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>4,460</td>
<td>2,829</td>
<td>1,631</td>
<td>4,014</td>
<td>8,231</td>
<td>1,501</td>
<td></td>
</tr>
<tr>
<td><strong>Coal-fired power plant</strong></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>6,280</td>
<td>3,065</td>
<td>3,215</td>
<td>5,652</td>
<td>1,841</td>
<td>4,393</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>6,155</td>
<td>3,047</td>
<td>3,108</td>
<td>5,540</td>
<td>1,804</td>
<td>4,306</td>
<td></td>
</tr>
<tr>
<td><strong>Outright power</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>8,760</td>
<td>4,380</td>
<td>4,380</td>
<td>7,884</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>8,760</td>
<td>4,380</td>
<td>4,380</td>
<td>7,884</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
For an analysis we examined the impact of the relevant price movement of coal and gas on the Variation Margin.

The maximum VM\textsubscript{Fuel} during a complete trading period \(S\) for a product \(i\) (e.g. coal or gas) can be written as:

\[
\text{Max}[\text{VM}_i(S)] = \text{Max} \left[ \sum_{s=1}^{S} \left( \sum_{t=s-1}^{s} V_{it} \right) \cdot (p_{i,s-1} - p_{i,s}) \right]
\]

\(\Delta V\text{M}_{\text{coal}}(s) = V_{\text{coal}} \cdot \Delta p_{\text{coal,s}} = V_{\text{elec}} \div \eta_{\text{coal}} \div 6.978 \frac{\text{MWh}_{\text{th}}}{t} \cdot \Delta p_{\text{coal,s}}\)

\(\Delta V\text{M}_{\text{gas}}(s) = V_{\text{gas}} \cdot \Delta p_{\text{gas,s}} = V_{\text{elec}} \div \eta_{\text{gas}} \cdot \Delta p_{\text{gas,s}}\)

\[\Delta V\text{M}_{\text{coal}}(s) = \frac{1}{0.44} \frac{\text{MWh}_{\text{el}}}{\text{MWh}_{\text{th}}} \cdot \frac{22.93 \text{ €}}{6.978 \text{ MWh}_{\text{th}}} = \text{€7.47}\]

\[\Delta V\text{M}_{\text{gas}}(s) = \frac{1}{0.54} \frac{\text{MWh}_{\text{el}}}{\text{MWh}_{\text{th}}} \cdot \frac{8.21 \text{ €}}{\text{MWh}_{\text{th}}} = \text{€15.19}\]

The reason for higher fuel VM needs for gas is given by the 2x higher relative price volatility of gas per MWh compared to the price volatility of coal.

* Period 01.01.07-31.12.09, standard deviation based on used market prices. In 2009: standard deviation based on prices used for cascading; furthermore for gas: 01.01.07-02.07.07: TTF prices.
As the efficiency of a power plant is important for the resulting VM, the relative difference between the fuel types varies...

<table>
<thead>
<tr>
<th>Coal-fired power plant</th>
<th>Gas-fired power plant</th>
<th>Relative delta</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>η (coal)</td>
<td>σ (coal)</td>
<td>Conversion factor</td>
<td>ΔVM (η (coal))</td>
</tr>
<tr>
<td>0.48</td>
<td>22.93</td>
<td>6.978</td>
<td>6.8</td>
</tr>
<tr>
<td>0.47</td>
<td>22.93</td>
<td>6.978</td>
<td>7.0</td>
</tr>
<tr>
<td>0.46</td>
<td>22.93</td>
<td>6.978</td>
<td>7.1</td>
</tr>
<tr>
<td>0.45</td>
<td>22.93</td>
<td>6.978</td>
<td>7.3</td>
</tr>
<tr>
<td>0.44</td>
<td>22.93</td>
<td>6.978</td>
<td>7.5</td>
</tr>
<tr>
<td>0.43</td>
<td>22.93</td>
<td>6.978</td>
<td>7.6</td>
</tr>
<tr>
<td>0.42</td>
<td>22.93</td>
<td>6.978</td>
<td>7.8</td>
</tr>
<tr>
<td>0.41</td>
<td>22.93</td>
<td>6.978</td>
<td>8.0</td>
</tr>
<tr>
<td>0.4</td>
<td>22.93</td>
<td>6.978</td>
<td>8.2</td>
</tr>
<tr>
<td>0.39</td>
<td>22.93</td>
<td>6.978</td>
<td>8.4</td>
</tr>
</tbody>
</table>

The higher (lower) the relative difference between the efficiency of the coal-fired vs. gas-fired power plant is, the higher (lower) is the absolute difference between the change in the VM\textsubscript{Fuel} of the coal plant vs. the change in the VM\textsubscript{Fuel} of the CCGT.
## 4. Results

Analogous to the Variation Margin, the same picture occurs for the Additional Margin requirements...

### Analysis on Additional margin requirements:
Maximum value in '000 €/MW

<table>
<thead>
<tr>
<th></th>
<th>Coal-fired</th>
<th>Gas-fired</th>
<th>Outright power</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AM Elec.</strong></td>
<td>-38</td>
<td>-30</td>
<td>-48</td>
</tr>
<tr>
<td><strong>AM Fuel</strong></td>
<td>-14</td>
<td>-27</td>
<td>-</td>
</tr>
<tr>
<td><strong>AM CO2</strong></td>
<td>-11</td>
<td>-4</td>
<td>-</td>
</tr>
<tr>
<td><strong>AM Total</strong></td>
<td>-64</td>
<td>-60</td>
<td>-48</td>
</tr>
<tr>
<td><strong>AM Elec.</strong></td>
<td>-43</td>
<td>-33</td>
<td>-54</td>
</tr>
<tr>
<td><strong>AM Fuel</strong></td>
<td>-16</td>
<td>-30</td>
<td>-</td>
</tr>
<tr>
<td><strong>AM CO2</strong></td>
<td>-13</td>
<td>-5</td>
<td>-</td>
</tr>
<tr>
<td><strong>AM Total</strong></td>
<td>-72</td>
<td>-67</td>
<td>-54</td>
</tr>
<tr>
<td><strong>AM Elec.</strong></td>
<td>-33</td>
<td>-26</td>
<td>-41</td>
</tr>
<tr>
<td><strong>AM Fuel</strong></td>
<td>-12</td>
<td>-23</td>
<td>-</td>
</tr>
<tr>
<td><strong>AM CO2</strong></td>
<td>-10</td>
<td>-4</td>
<td>-</td>
</tr>
<tr>
<td><strong>AM Total</strong></td>
<td>-54</td>
<td>-52</td>
<td>-41</td>
</tr>
</tbody>
</table>

Although the CCGT is significantly more efficient than the coal plant (54% vs. 44% → roughly 19% lower fuel needs), the maximum AM\textsubscript{Fuel} of the CCGT is significantly higher than that of the coal plant.

All values in 1000 €/MW. Margins can not be added and have to be seen independently as they represent maximum values of the separate margins over the time horizon of hedging. Negative sign: Margin to be paid, positive sign: Margin payment to be received.
4. Results

The reason for the differences in the Additional Margin requirements is given by the Additional Margin parameter…

Recalling the formula for the calculation of the AM:

\[ AM_s = \sum_{i=1}^{n} \sum_{s=1}^{m} \left( np_{is} \cdot cv_{i} \cdot AMP_{is} \cdot EMF_{is} \right) \]

- Volume
- Parameters fixed by the EEX/ECC

- The reason for this is the lower AMP\textsubscript{Coal} of the ECC in relative terms per MWh\textsubscript{th}:
  - The AMP\textsubscript{Coal} with 7.4 $/t \sim 5.3 \欧元/t\textsuperscript{*} translates into approximately 5.3 \欧元/6.978 MWh\textsubscript{th} or approx. 0.75 \欧元/MWh\textsubscript{th} vs. an AMP\textsubscript{Gas} of 1.70 \欧元/MWh\textsubscript{th} \textsuperscript{**}.
  - Therefore, the AMP\textsubscript{Gas} is more than 126% higher than the AMP\textsubscript{Coal}, which over-compensates the lower absolute volume in MWh of gas vs. coal.

* Applying for the period 01.01.07 – 31.12.09 an average exchange rate of \sim 0.711 \$/€, Source: Bloomberg, own calculations

** We applied the latest available data from the ECC as of Jan 2010 ([6]) for the AMPs for the complete hedging period. We did not apply the AMPs and EMFs from earlier time periods.
4. Results

In relative terms, compared to new build investment costs, the gas-fired power plant has the highest margin requirements...

Analysis on Total margin requirements: Maximum value in '000 €/MW

<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>Coal-fired</th>
<th>Gas-fired</th>
<th>Outright power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear hedging function</td>
<td>TM Total -124</td>
<td>TM Total -112</td>
<td>TM Total -255</td>
</tr>
<tr>
<td>Square root hedging function</td>
<td>TM Total -149</td>
<td>TM Total -116</td>
<td>TM Total -366</td>
</tr>
<tr>
<td>Quadratic hedging function</td>
<td>TM Total -92</td>
<td>TM Total -101</td>
<td>TM Total -148</td>
</tr>
</tbody>
</table>

Differences between the hedging strategies?

- Significant margin volatility as consequence of higher impact of electricity vs. fuel margin requirements
- Low margin volatility as consequence of compensating effects of electricity vs. fuel margin requirements
- High margin volatility as consequence of missing counter effects from fuel margins

** For coal: Average from expected costs for PP Eemshaven (NL) and Wola (PL): €3.7 bn for 2360 MW; for CCGT: PP Pembroke (GB): €1.25 bn for 2000 MW; for outright power: increase of capacity for existing run-of-river plant Albbruck-Dogern (Germany, Switzerland): €70 million for 24 MW, see [7].

Investment costs (in '000 €/MW)**

<table>
<thead>
<tr>
<th></th>
<th>Coal-fired</th>
<th>Gas-fired</th>
<th>Outright power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,570</td>
<td>625</td>
<td>2,920</td>
</tr>
</tbody>
</table>

Increase due to Margin requirements in % based on example

<table>
<thead>
<tr>
<th></th>
<th>6%-9%</th>
<th>16%-19%</th>
<th>5%-13%</th>
</tr>
</thead>
</table>

All values in 1000 €/MW. Negative sign: Margin to be paid, positive sign: Margin payment to be received.
5. Conclusions

- Relative advantage of coal plants with regard to the risk capital required for credit risk mitigation vs. gas-fired power plants as a consequence of a lower price change for coal in US$(or €)/MWh (in comparison to gas).

- Dependency of this result on the efficiency of the two plants:
  - The higher (lower) the relative delta between the efficiency of the coal- vs. gas-fired power plant, the higher (lower) is the absolute difference between the change in the Variation Margin for coal vs. the change in the Variation Margin for gas.

- Additional Margin requested by the ECC gives further advantage to coal power plants. So far, the Additional Margin parameter for gas is over two times as high as the AMP for coal per MWh_{th}.

- Margining is relevant for the value of a power plant:
  - In relative terms, compared with the so far actual investment costs, a gas-fired power plant has higher risk capital needs than a coal-fired power plant or a contract for outright power.

- Particularly, in years with higher volatility of market prices the impact of margining but also the applied hedging strategy can become very significant.

For further reference on our results see [11].
Discussion
## Selected references


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E-mail: Joachim.Lang@eon.com

\textsuperscript{b} Professor of Energy Economics and Management, Institute for Future Energy Consumer Needs and Behavior (FCN), Faculty of Business and Economics / E.ON Energy Research Center, RWTH Aachen University, Mathieustrasse 6, 52074 Aachen, Germany
Email: RMadlener@eonerc.rwth-aachen.de
Application of credit risk mitigation instruments

Source: Own illustration based on Pschick (2008), Ch.6

Hedged volumes of incumbents in the German electricity market as of last quarter 2008

<table>
<thead>
<tr>
<th>Delivery year by company</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.ON</td>
<td>70%</td>
<td>80%</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>RWE</td>
<td>&gt;60%</td>
<td>&gt;10%</td>
<td>&gt;20%</td>
<td>&gt;60%</td>
</tr>
<tr>
<td>Vattenfall</td>
<td>~80%</td>
<td>~40%</td>
<td>~15%</td>
<td>n.a.</td>
</tr>
<tr>
<td>EnBW</td>
<td>100%</td>
<td>&quot;by a majority&quot;</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>


E.ON IR1, 2009. E.ON Equity Story: Performance and Streamlining, March 2009
RWE IR, 2009. RWE Investor Relation Presentation: Steady course through stormy waters, Autumn 2009
Vattenfall ZF, 2009. Vattenfall Europe AG: The year 2008 in facts and figures
Hedging strategy E.ON

(a) Hedged volume vs. achieved price

(b) Hedging strategy and constraints

Source: E.ON CMD Generation 2009

Fundamentals of margining – description for types of margins at EEX/ECC

- **the Variation margin**: The Variation margin covers the risk of price changes in open positions. Every open net position of each market participant is valued against the actual market price (“mark-to-market-valuation”) and positive and also negative price related changes of the position are paid in cash from or into the account of the market participant.

- **the Premium margin**: This Margin is required for open short positions in options to cover potential losses that may arise from the close-out of the position at the respective actual market price.

- **the Initial margin** is meant to cover risk that occur from payment obligations of the intra-day trading for coal, gas, electricity and CO2 Emission rights. It represents the maximum expected payment amount of a trading participation.

- **the Additional margin**: This margin is used to cover risks from due obligations of additional calls for open positions in options and futures. Furthermore it shall cover possible additional close-out losses from open positions in futures and options in case those have to be closed out on the next trading day at possibly worse prices in comparison to those prices that have been used for the calculation of the Premium and Variation margin. Additional margins are also required for close-out and liquidation losses from open positions in futures for physically settled amounts once these futures are in the delivery period.

Source: [4], p.10-14
Fundamentals of margining – description for types of margins at EEX/ECC

- **the Spread margin**: Spread margins at ECC are only called for open opposing spread positions (long and short) in Futures for Emission rights within the same margin class (Classes for products with the same risk, see above). They cover additional close-out losses from open spread positions in futures in case a forced close-out can only be done at worse prices on the next trading day of the exchange in comparison to prices that have been used for the variation margins.

- **the Delivery margin**: Margin to hedge against risks arising from e.g. gas demands by the gas transmission system operator regarding deliveries of balancing gas in the case the Clearing member or the non-clearing member have not fulfilled its obligation during the settlement of the gas future. Delivery margins are generally required for all commodities trades with a real obligation for delivery (i.e. without possibility for financial netting)

- **the intra-day margin**: the intra-day margin covers all other risks for the Clearing company that arise from intra-day activities of each market participant. For the calculation all prize movement of the relevant securities, all Spot- and Futures- market trades, all close-outs of Futures and Options as well all deliveries and payments are taken into account. In the case that the total risk is higher than the individual share of the participant in the mutual collateral fund of the ECC, the participant is asked to provide a further margin. For this analysis the intra-day margin is not used.

Source: [4], p.10-14
### Power plant: Assumption Set

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>CCGT</th>
<th>Outright power</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>1 MW</td>
<td>1 MW</td>
<td>1 MW</td>
</tr>
<tr>
<td><strong>Efficiency (LHV) at optimal point of operation</strong></td>
<td>46%</td>
<td>56%</td>
<td>not relevant</td>
</tr>
<tr>
<td><strong>Actual efficiency (LHV)</strong></td>
<td>44%</td>
<td>54%</td>
<td>not relevant</td>
</tr>
<tr>
<td><strong>Availability factor</strong></td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td><strong>Fuel type</strong></td>
<td>Coal API#2</td>
<td>Natural gas</td>
<td>not relevant</td>
</tr>
<tr>
<td><strong>Assumed fuel transport- / flexibility charge</strong></td>
<td>8 €/t</td>
<td>2.5 €/MWh (th)</td>
<td>not relevant</td>
</tr>
<tr>
<td><strong>Other variable operation costs [in €/MWh]</strong></td>
<td>2.5</td>
<td>1.0</td>
<td>not relevant</td>
</tr>
<tr>
<td><strong>Specific CO₂ emission per MWh (th) fuel</strong></td>
<td>0.342</td>
<td>0.202</td>
<td>not relevant</td>
</tr>
<tr>
<td><strong>Resulting specific CO₂ emission per MWh (el)</strong></td>
<td>0.777</td>
<td>0.374</td>
<td></td>
</tr>
<tr>
<td><strong>Daily load factor (before availability) [in h]</strong></td>
<td>Calculated</td>
<td>Calculated</td>
<td>24</td>
</tr>
</tbody>
</table>

Source: Own assumptions, Konstantin (2009, p.293)
Nomenclature for hedging

- \( t \) ... delivery day;
- \( v_t \)...expected generation amount at delivery day \( t \) in MWh
- \( \alpha_p \)...share of peakload product needed, \( \alpha_b \)...share of baseload product needed with \( \alpha_b = 1 - \alpha_p \)
- \( S \)...total amount of hedging days,
- \( s = 1...S \)...specific hedging day;
- \( i \)...Nominator of fuel/electricity product (e.g. delivery year 2009);
- \( \eta \)... efficiency of the respective power plant
- \( k_{\text{coal}} \)... transfer factor from MWh\(_{\text{th}}\) vs. metric tons coal
- \( \text{eff}_{\text{fuel}} \)... specific emission factor per MWh\(_{\text{th}}\) of coal or gas.
For the period 01.01.2007-02.07.2007 no natural gas prices were available from EEX. For this period, we used as an approximation the TTF gas prices of Bloomberg. For the cascading of the prices in the delivery year 2009 we applied the following simplifications as an approximation:

- **Electricity prices:** Daily notations of the monthly futures for baseload and peakload (EEX Product Code “F1BM”, “F1PM”) for the delivery year 2009;
- **Natural Gas:** Arithmetic average of all monthly futures notations January-December (EEX Product Code “G0BM”) for the delivery year 2009 on each available trading day;
- **Coal:** Daily notations of the monthly futures (EEX Product Code “FT2M”) for the delivery year 2009;
- **CO2:** Daily notations of the futures for EUAs (EEX Product Code “F2PE”) for the delivery year 2009;
- **Weekend and public holidays:** Analogous to the hedging period.
Used Futures prices – delivery 2009

Prices in € per specific unit

- Peakload 2009 (€ per MWh)
- Baseload 2009 (€ per MWh)
- Coal 2009 (€ per ton)
- Natural Gas 2009 (€ per MWh)
- CO2 2009 (€ per ton)
Used Futures prices – delivery 2010

Prices in € per specific unit

- Peakload 2010 (€ per MWh)
- Baseload 2010 (€ per MWh)
- Coal 2010 (€ per ton)
- Natural Gas 2010 (€ per MWh)
- CO2 2010 (€ per ton)
Used prices – and margins

2009 & 2010

Applied hedging strategy:
constant linear hedge over 2 years with daily

Elec. product composition for hedge

2009
Peak  48.8%
Base  51.2%

2010
Peak  49.5%
Base  50.5%

Coal-fired

negative value: margin to be paid
positive value: margin payment received

- - - used peakload powerprice 2009  - - - used baseload powerprice 2009
Used spot prices: 2007 - 2009

Spot prices: Gas, Coal and CO2 in €/unit

Spot Price Electricity in €/MWh

Gas price (HHV)  CO2 price  Coal price  Electricity price
Used Assumptions – Dispatch Coal (before Availability)
BACKUP: Valuation procedure

Used Assumptions – Dispatch Coal (before Availability)
## Calculation of Additional Margin

**Determination of the Additional Margin for Electricity / Fuel – Example calculation for 1 delivery year**

### Nomenclature:
- \( n_{ps} \): net position of a certain contract \( i=1\ldots n \) at a certain time (e.g. trading day) \( s=1\ldots m \). For Emission rights the net position is replaced by a so-called net-non-spread-position
- \( c_{vi} \): standard contract volume for a certain contract \( i \). For e.g. a monthly future for Electricity delivery in January this would be 264 MWh
- \( \text{AMP}_s \): Additional Margin Parameter. This is a standard parameter which is fixed by the ECC on a regular basis. It represents the maximum negative price development of an underlying over a two-days trading period with a 99% probability based on the standard-normal distribution and is calculated as follows:
  \[
  \text{AMP}_s = 99\% \text{ Percentile of } N(0,1) \times 1.5 \times \sqrt{2} \times \text{Volatility of the underlying}
  \]
- \( \text{EMF}_s \): Expiry Month Factor. This standard parameter is also fixed by the ECC. It covers the close-out and liquidation risks for Monthly Futures during the phase of financial or physical fulfilment.

### Input
- Additional Margin Parameter as stated in [4], [6]: peak 4.2 €/MWh; base: 3.6 €/MWh; coal: 7.4 $/t; natural gas: 1.8 €/MWh; \( \text{CO}_2 \): 1.7 €/t. For simplification reasons assumed constant for complete period of time \( s \).
- Total net position x contract volume for Electricity, Coal, Gas
- Daily FX Rate (for transfer of coal costs in from $/t -> €/t)

### Formula

**Total Additional Margin:***

\[
AM_s = \sum_{i=1}^{n} \sum_{s=1}^{m} \left( n_{ps} \cdot c_{vi} \cdot \text{AMP}_{is} \cdot \text{EMF}_{is} \right)
\]
Results COAL PLANT
Results

Variation and Additional Margin for Futures contracts with delivery year 2009/2010 - linear hedging function, coal-fired power plant

2009 & 2010

Applied hedging strategy:
constant linear hedge over 2 years with daily trades

Elec. product composition for hedge

2009
Peak 48.8%
Base 51.2%

2010
Peak 49.5%
Base 50.5%

Coal-fired

negative value: margin to be paid
positive value: margin payment received

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume coal

Delivery year

Sold/Purchased Volumes in tons or MWh

Margin needs in tsd.€/MW

01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 – square root hedging function, coal-fired power plant

2009 & 2010

Margin needs in tsd.€/MW

Sold/Purchased Volumes in tons or MWh

Applied hedging strategy:
Square root hedge (731 trading days)

Elec. product composition for hedge

2009
Peak 48.8%
Base 51.2%

2010
Peak 49.5%
Base 50.5%

Coal-fired

negative value: margin to be paid
positive value: margin payment received

Total variation margin electricity - short position
CO2 variation margin
Total additional margin requirement
Total volume short position
Total purchased volume CO2 in t

Fuel variation margin
Total commodity variation margin
Total margin requirement
Total purchased volume coal
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 - quadratic hedging function, coal-fired power plant

2009 & 2010

Margin needs in tsd.€/MW

Applied hedging strategy:
 Quadratic hedge (731 trading days)

Elec. product composition for hedge

2009
 Peak 48.8%
 Base 51.2%

2010
 Peak 49.5%
 Base 50.5%

Coal-fired

Results

Sold/Purchased Volumes in tons or MWh

Fuel variation margin
Total commodity variation margin
Total margin requirement
Total purchased volume coal

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
Results

Variation and Additional Margin for Futures contracts with delivery year 2009/2010 – best case hedging, coal-fired power plant

2009 & 2010

Margin needs in tsd.€/MW

- Applied hedging strategy:
  - Best Case

- Elec. product composition for hedge
  - 2009
    - Peak: 48.8%
    - Base: 51.2%
  - 2010
    - Peak: 49.5%
    - Base: 50.5%

Coal-fired

- negative value: margin to be paid
- positive value: margin payment received

- 01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t

- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume coal
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 – worst case hedging, coal-fired power plant

2009 & 2010

Applied hedging strategy:

Worst Case

Elec. product composition for hedge

2009
Peak 48.8%
Base 51.2%

2010
Peak 49.5%
Base 50.5%

Coal-fired

Results

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume coal

Delivery year

- 01.01.2007 - 01.09.2007 - 01.01.2008 - 01.05.2008 - 01.09.2008 - 01.01.2009 - 01.05.2009 - 01.09.2009

Marginal needs in tsd.€/MW

Sold/Purchased Volumes in tons or MWh

- 0 - 1,000 - 2,000 - 3,000 - 4,000 - 5,000 - 6,000 - 7,000 - 8,000 - 9,000 - 10,000
Results OUTRIGHT POWER
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 - linear hedging function, outright power

2009 & 2010

Margin needs in tsd.€/MW

Sold/Purchased Volumes in tons or MWh

Applied hedging strategy:
constant linear hedge over 2 years with daily trades

Elec. product composition for hedge

2009
Peak 0.0%
Base 100.0%

2010
Peak 0.0%
Base 100.0%

Outright

negative value: margin to be paid
positive value: margin payment received

01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 - square root hedging function, outright power

2009 & 2010

Margin needs in tsd.€/MW

Sold/Purchased Volumes in tons or MWh

Applied hedging strategy:
Square root hedge (731 trading days)

Elec. product composition for hedge

2009
Peak 0.0%
Base 100.0%

2010
Peak 0.0%
Base 100.0%

Outright

negative value: margin to be paid
positive value: margin payment received

01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

- Total variation margin electricity - short position
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 - quadratic hedging function, outright power

2009 & 2010

Margin needs in tsd.€/MW

Sold/Purchased Volumes in tons or MWh

Applied hedging strategy:
- Quadratic hedge (731 trading days)

Elec. product composition for hedge
- 2009:
  - Peak: 0.0%
  - Base: 100.0%
- 2010:
  - Peak: 0.0%
  - Base: 100.0%

Outright
- negative value: margin to be paid
- positive value: margin payment received

01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

Legend:
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume
- Total volume short position
- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total purchased volume CO2 in t
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 – best case hedging, outright power

2009 & 2010

Applied hedging strategy:
Best Case

Elec. product composition for hedge
2009
Peak 0.0%
Base 100.0%

2010
Peak 0.0%
Base 100.0%

Outright

negative value: margin to be paid
positive value: margin payment received

01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 – worst case hedging, outright power

**2009 & 2010**

**Margin needs in tsd. €/MW**

- **Applied hedging strategy:**
  - Worst Case

**Elec. product composition for hedge**

- **2009**
  - Peak: 0.0%
  - Base: 100.0%

- **2010**
  - Peak: 0.0%
  - Base: 100.0%

**Outright**

- neg. value: margin to be paid
- pos. value: margin payment received

- **Total variation margin electricity - short position**
- **CO2 variation margin**
- **Total additional margin requirement**
- **Total volume short position**
- **Total purchased volume CO2 in t**

- **Fuel variation margin**
- **Total commodity variation margin**
- **Total margin requirement**
- **Total purchased volume**

**Sold/Purchased Volumes in tons or MWh**

- 01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

---

**Results**

E.ON Energy Research Center
Results

Results Gas
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 - linear hedging function, Gas

2009 & 2010

Margin needs in tsd.€/MW

<table>
<thead>
<tr>
<th>Year</th>
<th>Peak</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>55.3%</td>
<td>44.7%</td>
</tr>
<tr>
<td>2010</td>
<td>63.4%</td>
<td>36.6%</td>
</tr>
</tbody>
</table>

CCGT

negative value: margin to be paid
positive value: margin payment received

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume gas
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 – square root hedging function, CCGT

2009 & 2010

Margin needs in tsd.€/MW

Sold/Purchased Volumes in tons or MWh

Applied hedging strategy:
Square root hedge (731 trading days)

Elec. product composition for hedge

2009
Peak 55.3%
Base 44.7%

2010
Peak 63.4%
Base 36.6%

CCGT

negative value: margin to be paid
positive value: margin payment received

01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

- Red: Total variation margin electricity - short position
- Blue: Total variation margin
- Green: CO2 variation margin
- Orange: Total additional margin requirement
- Yellow: Total volume short position
- Cyan: Total purchased volume CO2 in t
- Gray: Fuel variation margin
- Light blue: Total commodity variation margin
- Dark blue: Total margin requirement
- Dashed: Total purchased volume gas
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 - quadratic hedging function, CCGT

2009 & 2010

Margin needs in tsd. €/MW

Applied hedging strategy:
Quadratic hedge (731 trading days)

Elec. product composition for hedge

2009
- Peak: 55.3%
- Base: 44.7%

2010
- Peak: 63.4%
- Base: 36.6%

CCGT

Fuel variation margin
Total commodity variation margin
Total margin requirement
Total purchased volume gas

Total variation margin electricity - short position
Total additional margin requirement
Total volume short position
Total purchased volume CO2 in t
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 – best case hedging, CCGT

2009 & 2010 Margin needs in tsd.€/MW

Applied hedging strategy:
Best Case

Elec. product composition for hedge

2009
Peak 55.3%
Base 44.7%

2010
Peak 63.4%
Base 36.6%

CCGT

01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

Sold/Purchased Volumes in tons or MWh

- Total variation margin electricity - short position
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume gas
Variation and Additional Margin for Futures contracts with delivery year 2009/2010 – worst case hedging, CCGT

2009 & 2010

Margin needs in tsd.€/MW

Sold/Purchased Volumes in tons or MWh

Delivery year

Applied hedging strategy:
Worst Case

Elec. product composition for hedge

2009
Peak 55.3%
Base 44.7%

2010
Peak 63.4%
Base 36.6%

CCGT

01.01.2007 01.05.2007 01.09.2007 01.01.2008 01.05.2008 01.09.2008 01.01.2009 01.05.2009 01.09.2009

negative value: margin to be paid
positive value: margin payment received

- Total variation margin electricity - short position
- CO2 variation margin
- Total additional margin requirement
- Total volume short position
- Total purchased volume CO2 in t
- Fuel variation margin
- Total commodity variation margin
- Total margin requirement
- Total purchased volume gas