Optimisation of Trading Strategies in Incomplete Power and Gas Markets

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Agenda

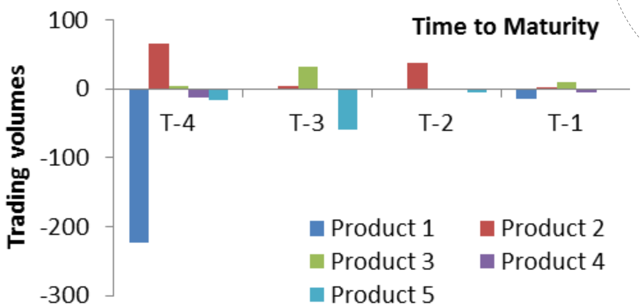
- Challenges and General Framework
- Application Examples – Optimisation of
  1. Physical and Virtual Gas Storages
  2. Trading Strategies for Renewables
  3. Internal Transfer Prices for Power Generation and Trading
- Take-home Messages

Challenges and General Framework

Proper management of power and gas portfolios is a key success factor

Objective: Trading Strategies

- **Definition**: Allocation of trading volumes over time (for a certain power and gas portfolio)
- A trading strategy can be formulated as a matrix over discrete trading times and products



Challenge:
What is the optimal trading strategy?

- Optimal trading on energy spot- and forward markets
- Optimal usage of storage capacities (feed-in / feed-out strategy)
- Optimal trading of uncertain Renewable capacities

Practical Issues and Limitations

- **Incompleteness**: Price risk is non-tradable (no forward contracts on a hourly basis, limited storability), concept of risk-neutral replication fails.
- **Uncertain volumes**: The availability of production capacities and renewable production (feed-in) is uncertain

Due to incomplete spot markets and volume risk, the evaluation and optimisation of trading strategies is based on the balancing of chances and individual risk preferences.

The evaluation of trading strategies under individual risk preferences is captured by the theory of expected utility

Formulation of the evaluation framework

Theory

- Risky trading strategies can be compared by their **expected utility**:

$$EU = \langle u(W(\pi)) \rangle = u(\langle W(\pi) \rangle - RP)$$

- Here, u is the utility function, $W(\pi)$ the final wealth of the chosen trading strategy π, $\langle \cdot \rangle$ the expected value and RP the **risk premium**

Optimal strategy

- The **optimal trading strategy** π^* maximizes the objective function OF which can be derived by a Taylor expansion of EU:

$$EU \approx OF(W(\pi^*)) = \langle W(\pi^*) \rangle - \frac{1}{2} \cdot \sigma^2(W(\pi^*)) \cdot \omega$$

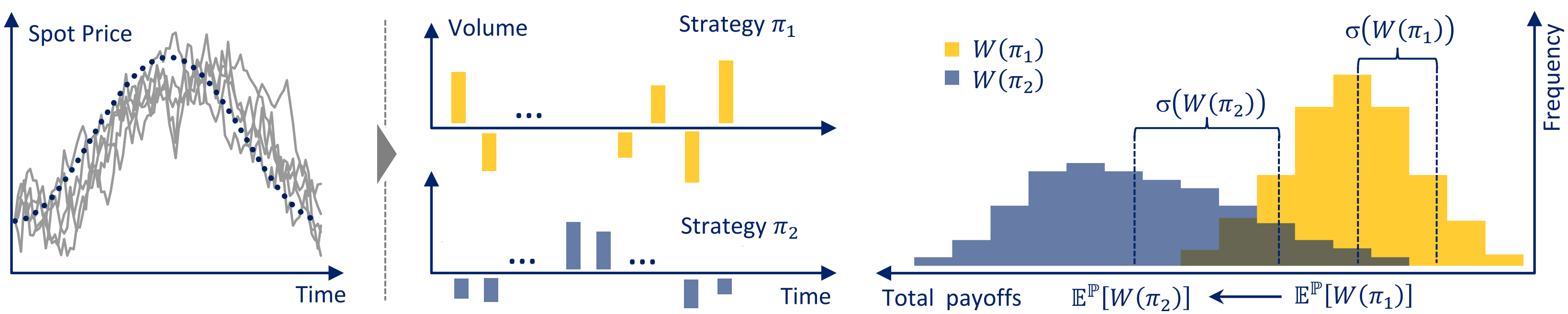
- Here, $\omega = -\frac{d^2u}{dW^2} \Big/ \frac{du}{dW}$ is the (absolute) **risk aversion**

Where does ω come from?

- An **implicit risk aversion** can be determined by
  - Historical prices for (liquidly traded) contracts with remaining spot market risk (e.g. fix load delivery contracts)
  - Certain limits for key risk figures (VaR, PaR) that should not be violated
- A **strategic risk aversion** (regularly set by management) can be used to easily control the optimisation model.

Example strategies π_1 & π_2

$\mathbb{E}^{\mathbb{P}}[W(\pi_2)] < \mathbb{E}^{\mathbb{P}}[W(\pi_1)]$



Die Herausforderung besteht darin, die Theorie in die Praxis umzusetzen und einen einfachen Ansatz für die Optimierung der erwarteten risikoadjustierten Erlöse zu finden.

Application Examples

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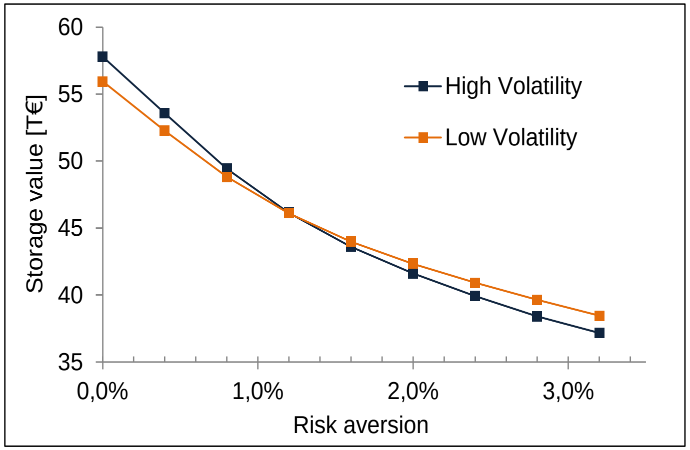
Practical Example: Valuation of Gas Storages

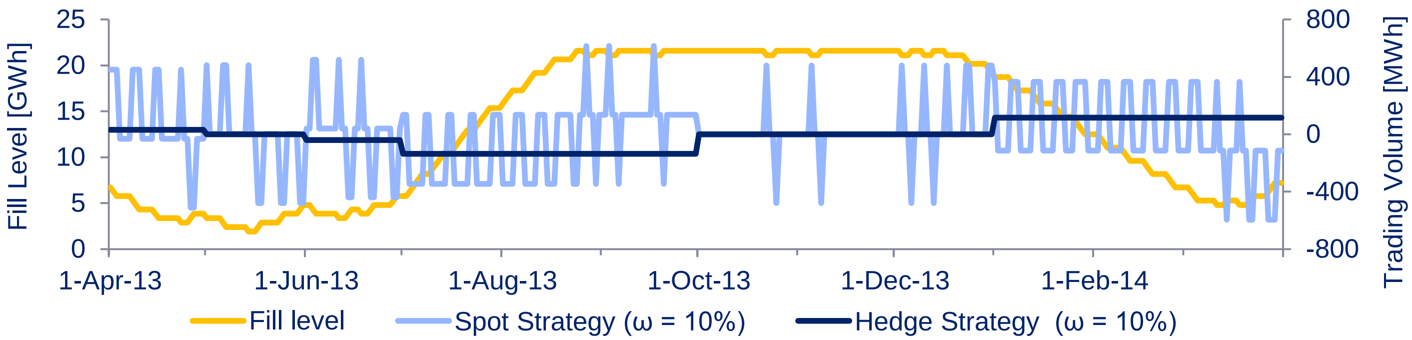
Chances and risks for the gas storage owner

- **Chances**: Utilization of price spread, **Risks**: Expected price spreads will not be realized
- The storage facility is replicated by so-called valuation instruments
  - α: Positions in N **non-tradable instruments** (intrinsic: calendar spreads, extrinsic: calendar spread options, swing options). Value can be earned by waiting.
  - β: Positions in M **tradable instruments** (exchange traded futures). Risk will be reduced by hedging now. → $\alpha + \beta$: Physical feed-in / feed-out strategy
- Optimal strategy π^* (fully describes all payoffs of tradable and non-tradable instruments):

$$V(t,\pi^*) = \sup_{\pi=\{\bar{\alpha},\bar{\beta}\}} \left\{ \mathbb{E}^{\mathbb{P}}\left[\sum_{i=1}^{N} P_i^{nh}(\bar{\alpha}^i) \mid \mathcal{F}_t\right] - \frac{\omega}{2}\sigma^2\left[\sum_{i=1}^{N} P_i^{nh}(\bar{\alpha}^i) \mid \mathcal{F}_t\right] + \mathbb{E}^{\mathbb{Q}}\left[\sum_{j=1}^{M} P_j^{h}(\bar{\beta}^j) \mid \mathcal{F}_t\right] \right\}$$

$$\pi = \{\alpha_1^1, \dots, \alpha_{n_1}^1, \dots, \alpha_1^N, \dots, \alpha_{n_N}^N, \beta_1^1, \dots, \beta_{m_1}^1, \dots, \beta_1^M, \dots, \beta_{m_M}^M\} \equiv \{\bar{\alpha}^1, \dots, \bar{\alpha}^N, \bar{\beta}^1, \dots, \bar{\beta}^M\} = \{\bar{\alpha}, \bar{\beta}\}$$





- Valuation date: 19.02.2013
- Working gas volume: 21600 MWh
- Feed-in/ feed-out capacity: 20 MWh
- Start fill level: 7200 MWh
- End fill level: 7200 MWh
- Injection costs: 0,39 €/MWh
- Withdrawal costs: None
- Runtime: 1 year (01.04.2013 – 31.03.2014)
- Storage value (ω = 0): 56.400 €

Valuing gas storage facilities under the firm‘s specific risk preferences provides an economic view on investment decisions and allows for replication of market prices.

Transmission system operators (TSOs) in Germany are obliged to market renewable energy supply (RES) at the spot market of a power exchange

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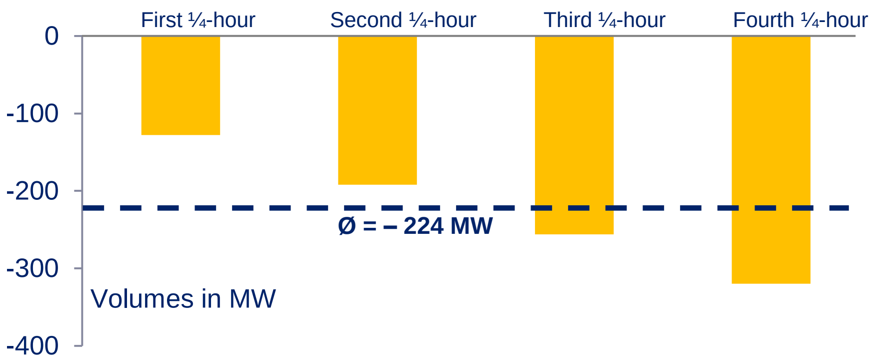
Spot markets

- **Day Ahead (DA) Market**
  – Hourly forecast-volumes for the next day are placed in the EPEX Day Ahead Auction which closes at 12pm
- **Intraday Market**
  – Forecast deviations can be traded on the ID market
  – Continuous trading starts at 3pm on the day before delivery
  – Trading quarterly hours and full delivery hours is possible until 45 min before delivery ('Gate Closure')
  – TSOs have to close their position according to the latest forecast

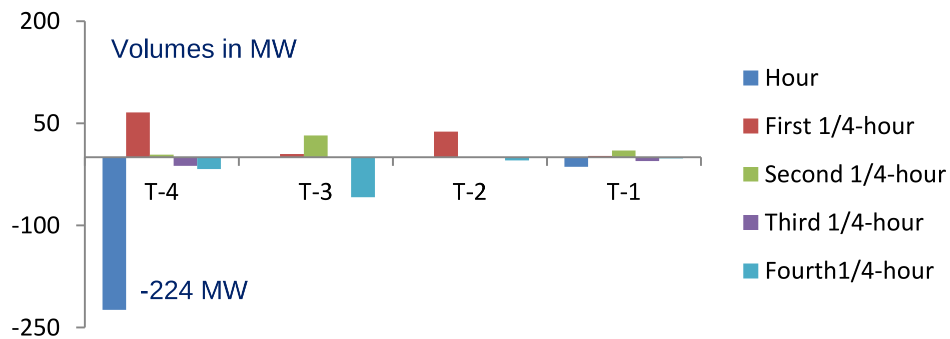
Objectives and requirements

- **Objectives:**
  – Determination of an optimal ID trading strategy (TS)
  – TS consists of an allocated trading volumes for 5 products: Full delivery hour and 4 ¼-hours.
- **Requirements:**
  – Minimise expected costs without taking strategic positions in operating reserve.
  – Price and volume risks have to be considered.

Expected ID position in T-4



ID Trading: Optimal allocation of volumes in T-4 (Buy: -, Sell +)



RES ID trading strategies maximise the risk adjusted gains taking into account both volume and price uncertainty.

The evaluation framework can also be used to determine firm-wide optimal transfer prices

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Firm-wide result

$$P\left(TP^{(1)},TP^{(2)}\right) = \sum_i \left\{ L_i \cdot EP_i^{(2)} - \left(L_i - l_i - \sum_{k<i} N_{ki}\right)\cdot S_i - \sum_{k>i} F_{ik}N_{ik} - l_i \cdot EP_i^{(1)} \right\}$$

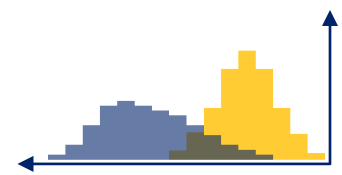
Optimisation

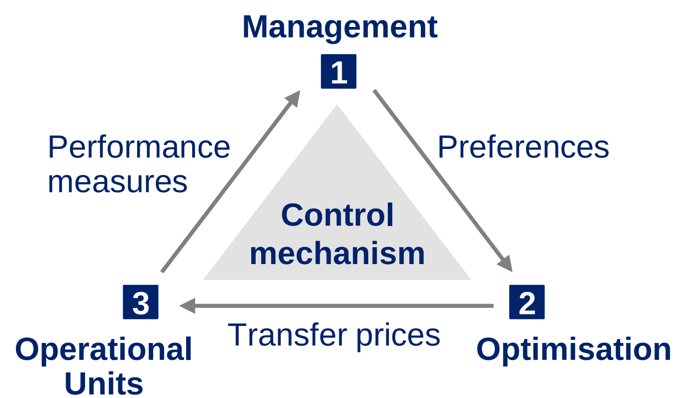
$$max_{TP^{(1)},TP^{(2)}} \quad E[P] - \frac{1}{2}\omega \cdot var(P)$$

Realised operational results

1. Production: $l_i \cdot (TP_i^{(1)} - EP_i^{(1)})$
2. Trading: $L_i \cdot TP_i^{(2)} - (L_i - l_i - \sum_{k:k<i} N_{ki}) \cdot S_i - \sum_{k:k>i} F_{ik}N_{ik} - l_i \cdot TP_i^{(1)}$
3. Sales: $L_i \cdot (EP_i^{(2)} - TP_i^{(2)})$

- L_i ,l_i : planned sales and production volumes for period i
- $EP^{(1)}$, $EP^{(2)}$: production cost and retail price (external prices)
- S_i : wholesale market prices
- F_{ik}, N_{ik}: Futures prices and volumes (start in period i, mature in k)





Transfer prices incentivise production, sales and trading behavior. The management can frequently adjust transfer prices in order to control that behavior on the basis of certain performance measures.

Take-home Messages

Take-home Messages

- Due to incomplete spot markets, future cash flow risks cannot be hedged and thus have to be taken.
- Trading strategies are – in contrast to complete capital markets – based on the theoretical concept of expected utility and risk aversion.
- However, meeting appropriate assumptions (e.g. constant risk aversion) leads to a practical valuation framework.
- The core of the evaluation framework is to reduce the whole cash flow distribution into a single value, weighting the distribution's *expected value (the center)* and the *variance (square of the width)* via the risk aversion parameter.
- d-fine already applied the framework in several projects
  - Optimal trading of uncertain renewable volumes
  - Valuation and optimal usage of gas storages
  - Firm-wide optimal choice of transfer prices

Many thanks for your attention!

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