Enhancing Profits in Trading of Gas Assets

Exploring the Value of Flexibility using Stochastic Optimization

- Scenario generation of gas market forward curves
- Scenario tree based stochastic optimization
- Benchmark analysis against rolling intrinsic

Flame 2019, Presentation at Traders‘ day, 13.05.2019

Dr. Georg Ostermaier

decision trees
stochastic optimization

Agenda

- Introduction of Decision Trees GmbH
- Scenario Tree based Stochastic Optimization - Overview
- Application on Asset Backed Gas Trading
- Benchmark against Rolling Intrinsic
- Conclusions

Decision Trees

- Founded in 2008
- Based in Munich (Germany) and St. Gallen (Switzerland)

- Software/consulting in **mathematical methods for the energy industry**
- Optimization systems for the **electricity sector**
- Optimization systems for the **gas sector**
- **Stochastic Optimization** of assets and asset portfolios

- Current Focus in Research:
  - **Stochastic Hydro Optimization**
  - **Stochastic Gas Storage/LNG Valuation**
  - Optimization of Consumer Portfolios

Problem Setting

- Low time spreads in gas markets
  - Traditional operation of gas assets with back-to-back trading does not yield sufficient profits anymore
- Uncertain evolution of prices and volatilities
  - More market participants have made markets more liquid but hard to predict
  - Trading of open positions involves increased risk
- Needed: Flexibility Valuation Model which
  - Considers spot and forward trading
  - Allows for (limited) open positions in trading
  - Respects Risk limits (max open physical and financial positions)

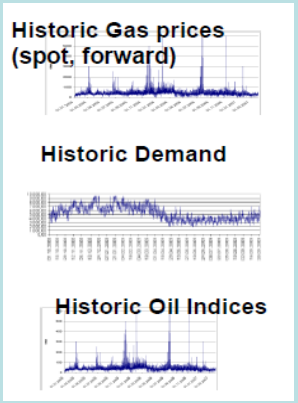
Conventional Valuation Models for Flex Gas Assets

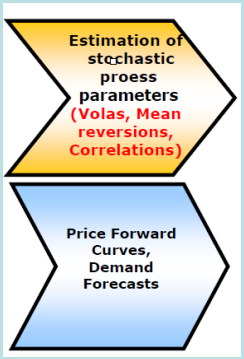
- **Least Squares Monte Carlo** (Backward/Forward-Iteration)
  - Benefit: Path dependency of decision process is considered
  - Drawback: Only day ahead model, no forward price model
    Not applicable for large and complex portfolios
- **Rolling Intrinsic**
  - Benefit: Joint valuation against day ahead and forward market
  - Drawback: Back-to-Back-Trading, no open positions, no risk affinity
- **Delta Hedging**
  - Benefit : Joint valuation against day ahead and forward market
    Consideration of volatilities/scenarios
  - Drawback: Back-to-Back-Trading, no open positions, no risk affinity

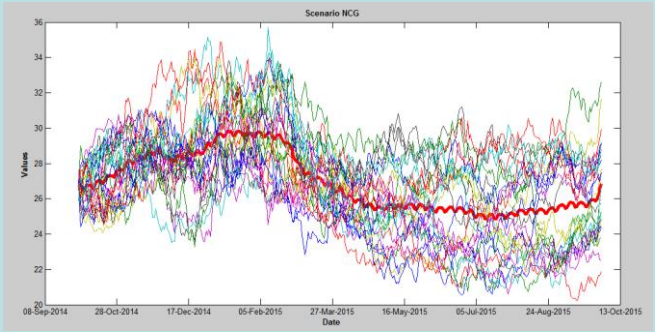
Stochastic Optimization - Overview

Two major steps of Stochastic Optimization

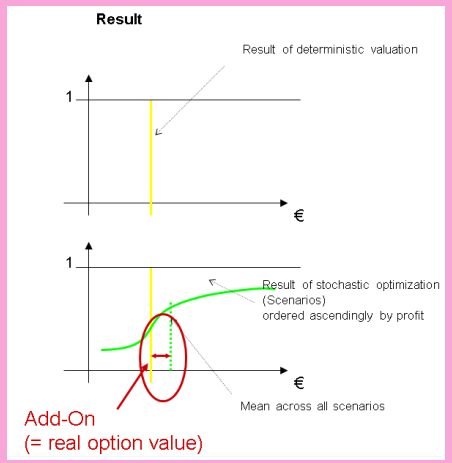
Step 1 : Price Pathing - PARAMETER based price scenario development

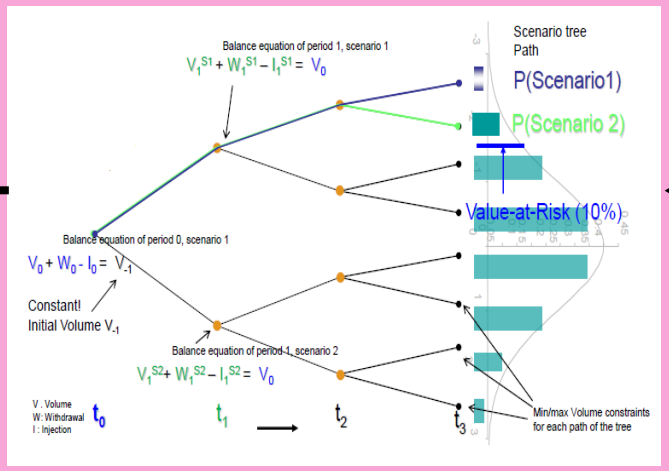






Step 2 : Volume allocation - based on average optimal decisions





Asset Constraints
Risk Constraints

Solver (CPLEX™)

Maximization of expected profit across all scenario paths

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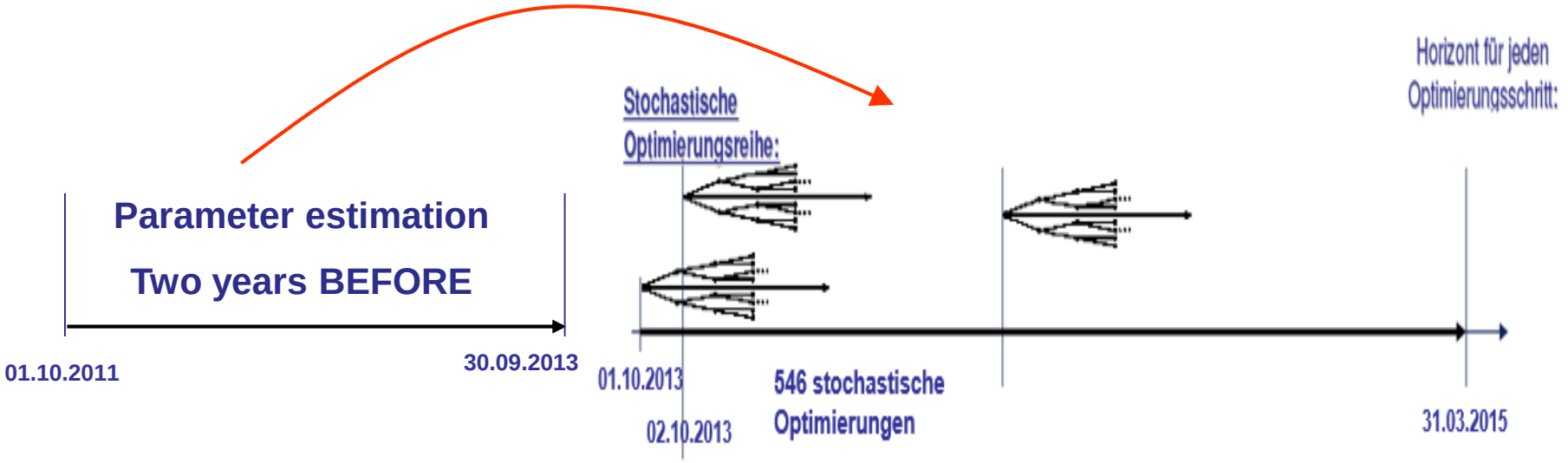
Parameter estimation (variances, covariances)

Transfer of parameters
from the past
into the future



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Joint Scenario Generation of Risk Factors

- At least three risk factors: Spot, Month-Ahead, Year-Ahead
- Optionally further rusk factors: Month-Ahead+2, Quarter-Ahead
- Correlation between risk factors

Day Ahead Prices: Differentiation between Summer and Winter vola

Jumps can be modelled (e.g. cold winter days)

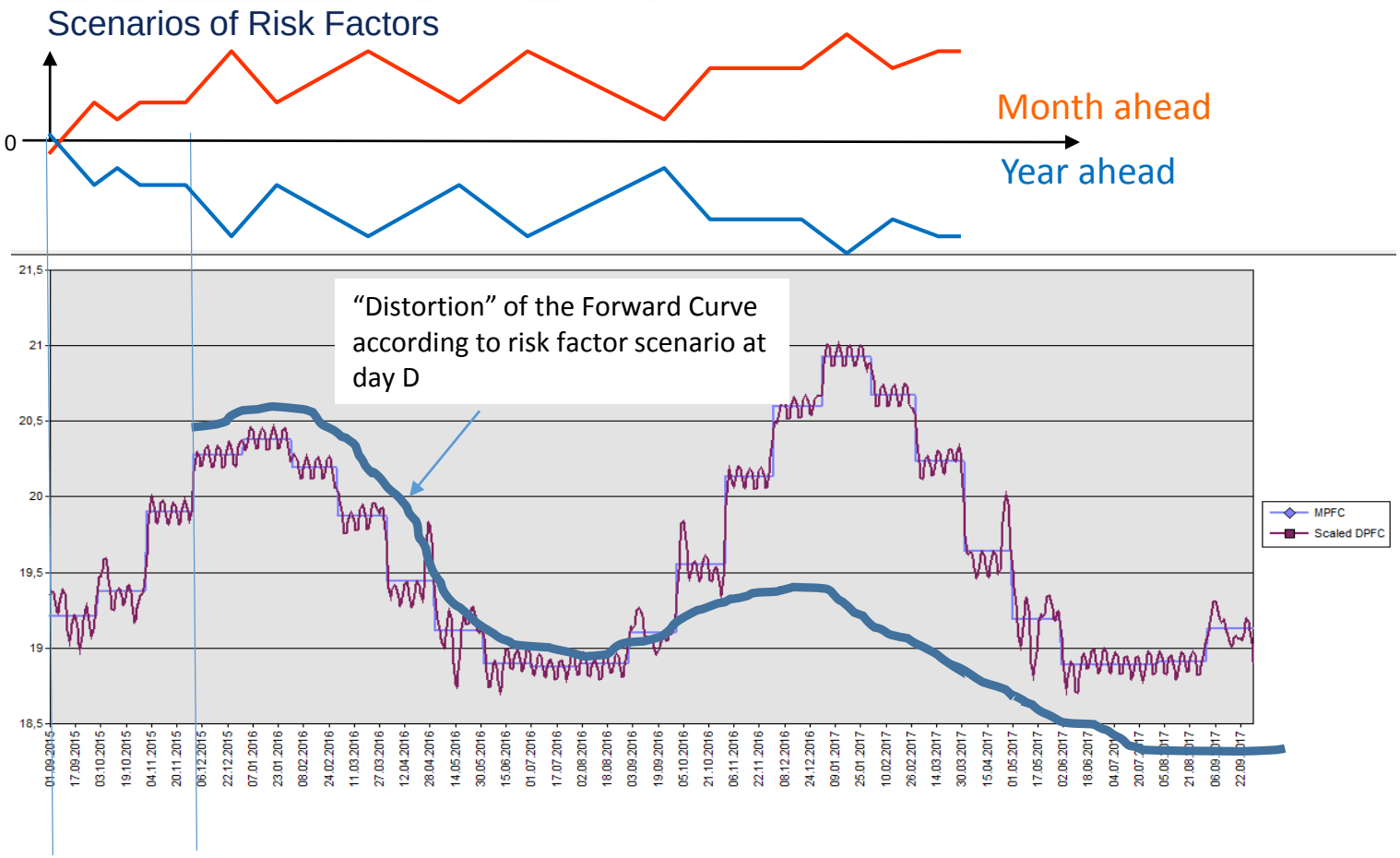
Spot (Day-Ahead):
$$\mathrm{d}G_t^{(s/w)} = \alpha^{(s/w)}(X_{1,t}^{(G)} - G_t^{(s/w)})\mathrm{d}t + \sigma_G^{(s/w)}\mathrm{d}W_t^{(G_1)} + f_t^{(s/w)\uparrow}\kappa_t^{\uparrow}\mathrm{d}v_t^{\uparrow}$$

Month-Ahead:
$$dX_1^{(G)} = \sigma_1\left(dW_{1,t}\rho_{1,1}\right)$$

Year-Ahead:
$$dX_2^{(G)} = \sigma_2\left(dW_{1,t}\rho_{1,2} + dW_{2,t}\rho_{2,2}\sqrt{1-\rho_{1,2}^2}\right)$$

Quarter-Ahead:
$$dX_3^{(G)} = \sigma_3\left(dW_{1,t}\rho_{1,3} + dW_{2,t}\rho_{2,3}\sqrt{1-\rho_{1,3}^2} + dW_{3,t}\rho_{3,3}\sqrt{1-\rho_{1,3}^2}\sqrt{1-\rho_{2,3}^2}\right)$$

Forward Scenario Generation of Risk Factors



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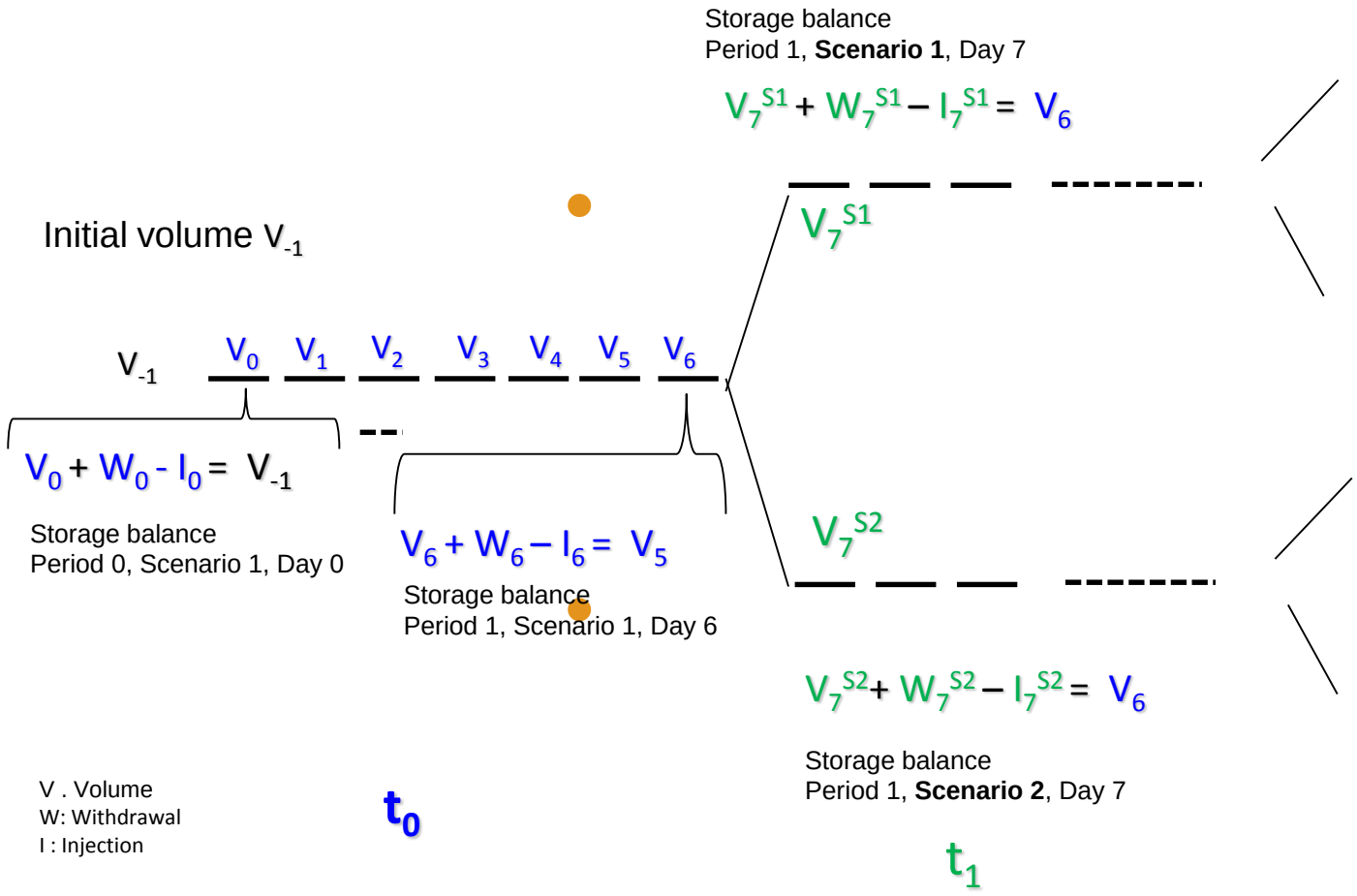
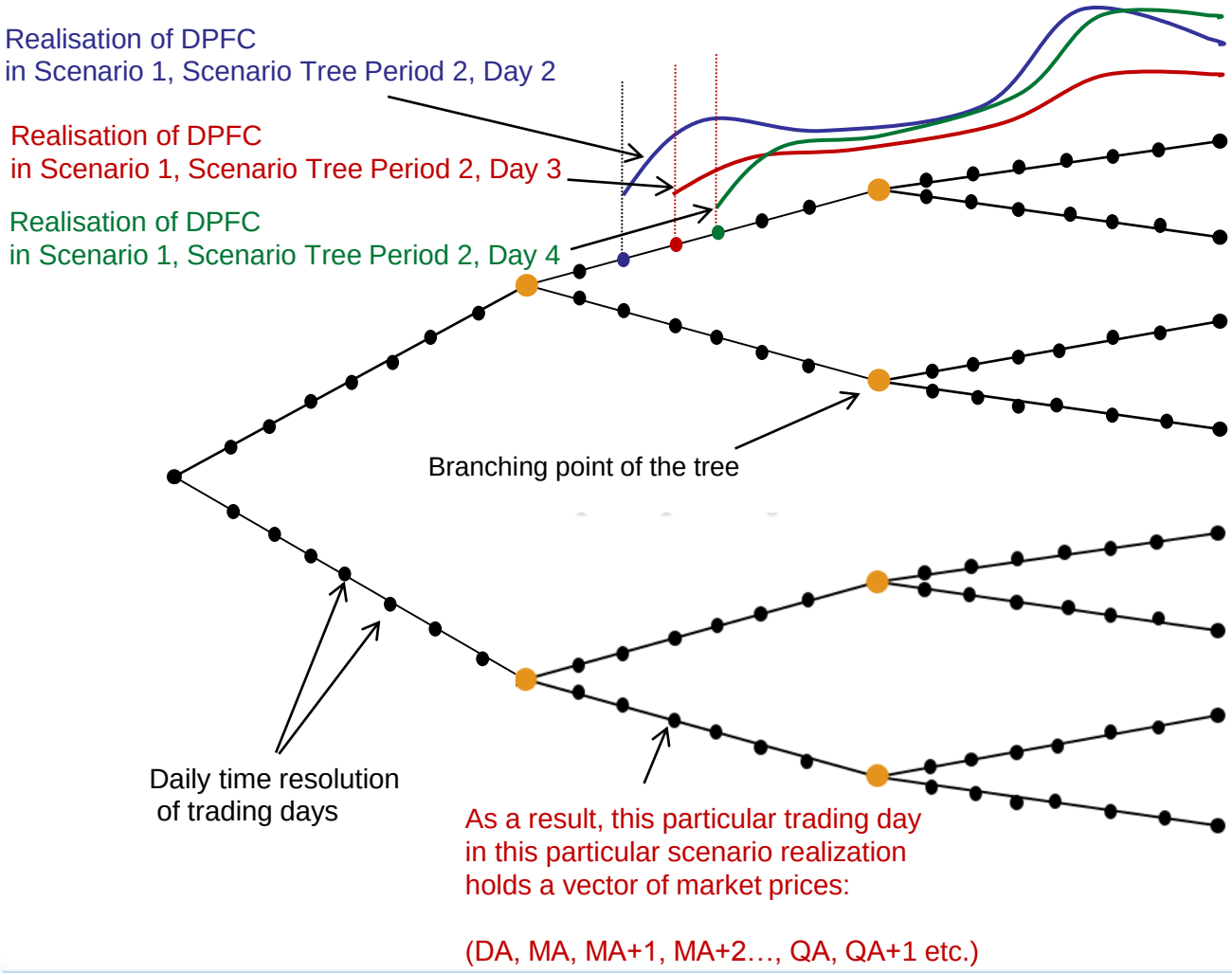
Daily time resolution in the scenario tree model



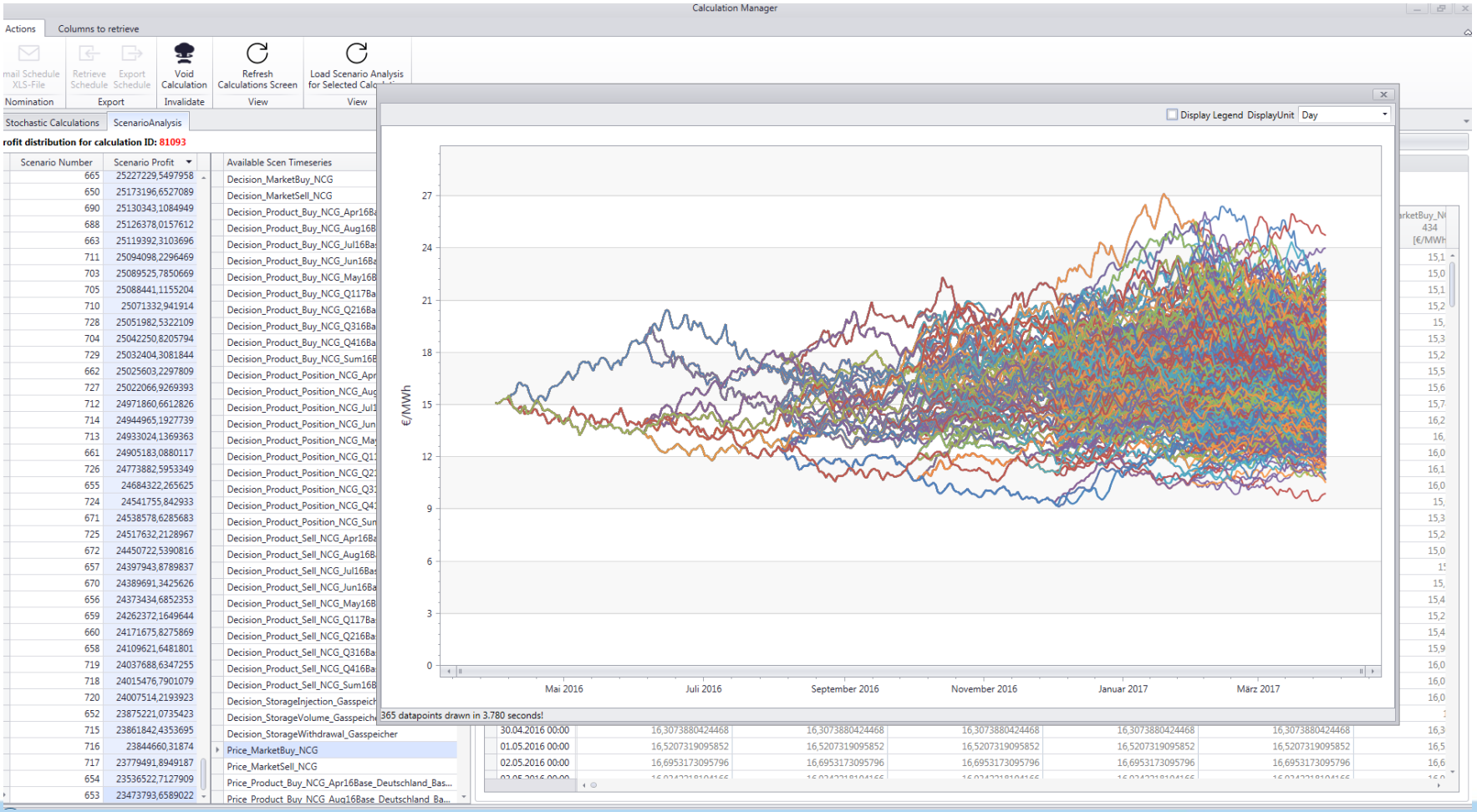
Scenario Tree Generation:
Every day and every scenario holds a full Forward Curve until the end of the planning horizon



- Every realization of the DPFC scenario starts at the relevant trading day and lasts until the very end of the planning horizon
- Each realization of the DPFC in each path of the tree at every day implicitly holds all prices of the traded products at the time. Averaging the DPFC realization across the delivery period of individual products results the realization of the product price senarios at the day .
- All Averages of all DPFC realizations across the tree meet the value of the original DPFC that has been used as an input for the scenario tree generation.

Scenario Tree of Day Ahead Prices

Day Ahead Prices



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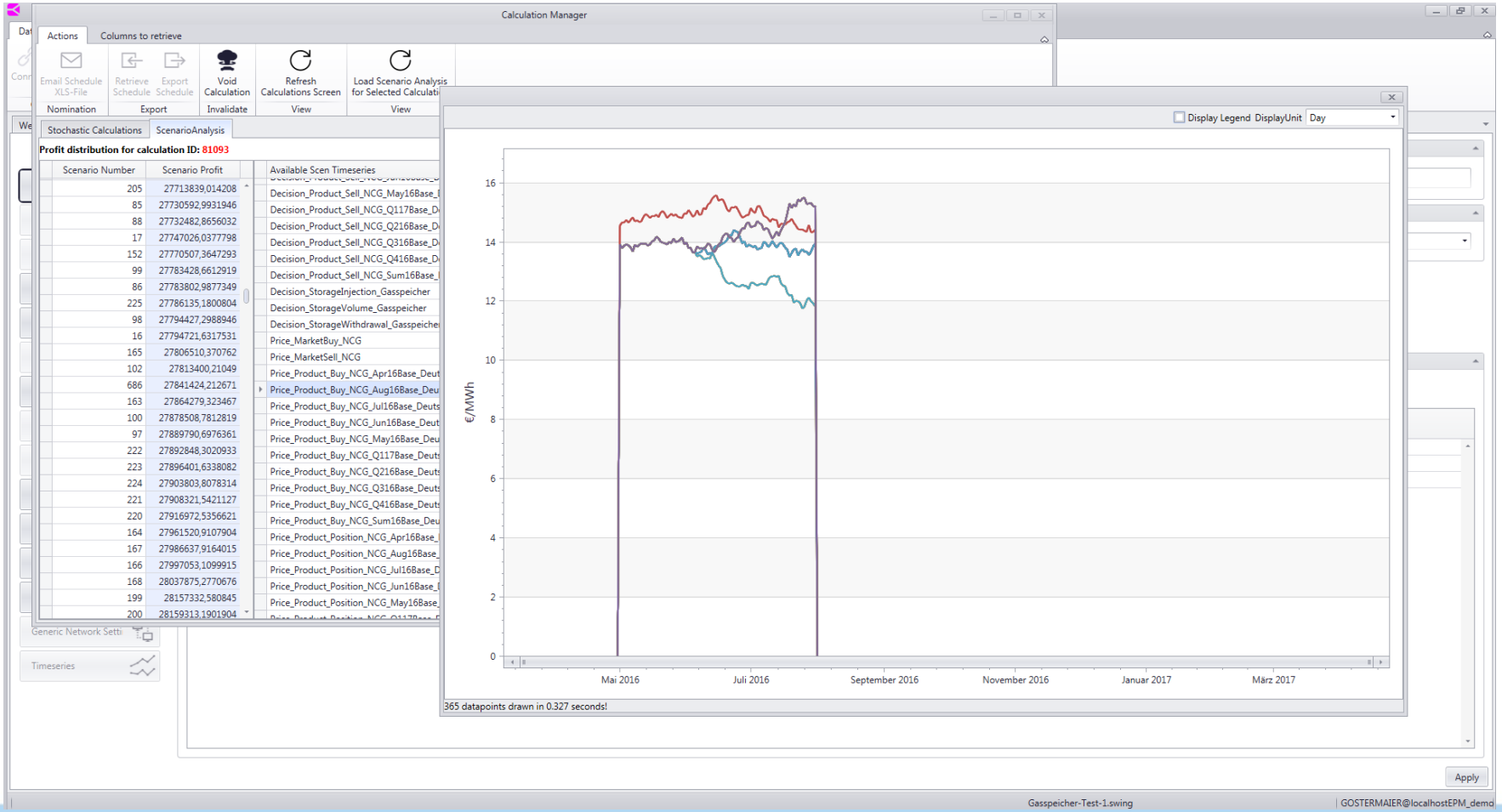
Scenario Tree of Forward Product Prices

Price scenarios for August 2016 during its trading period



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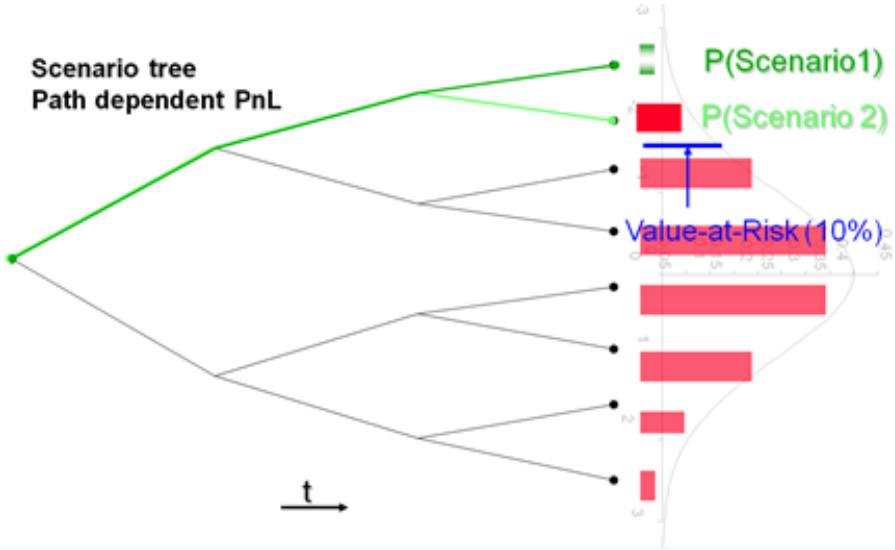
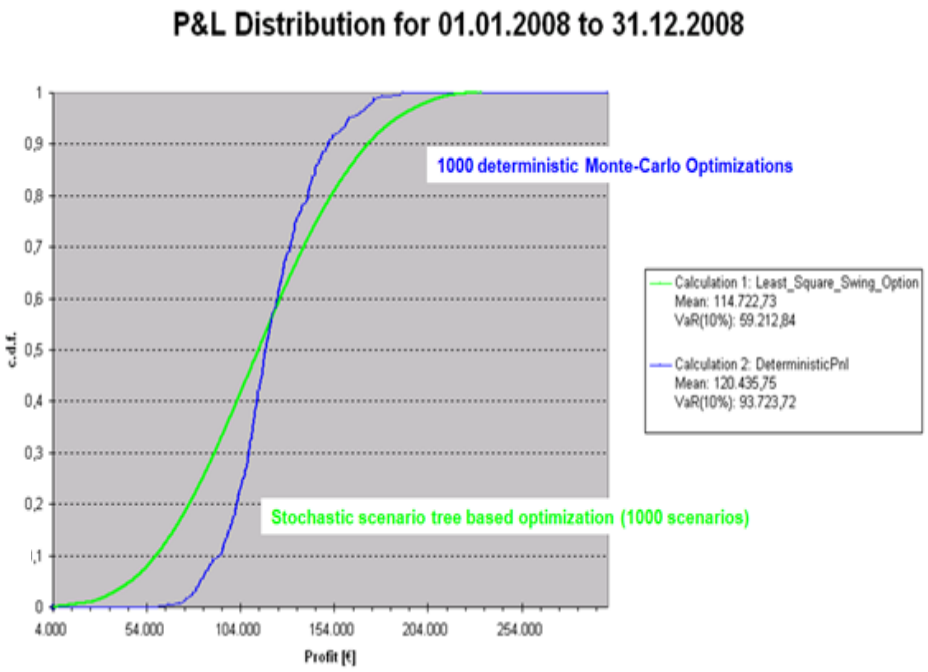
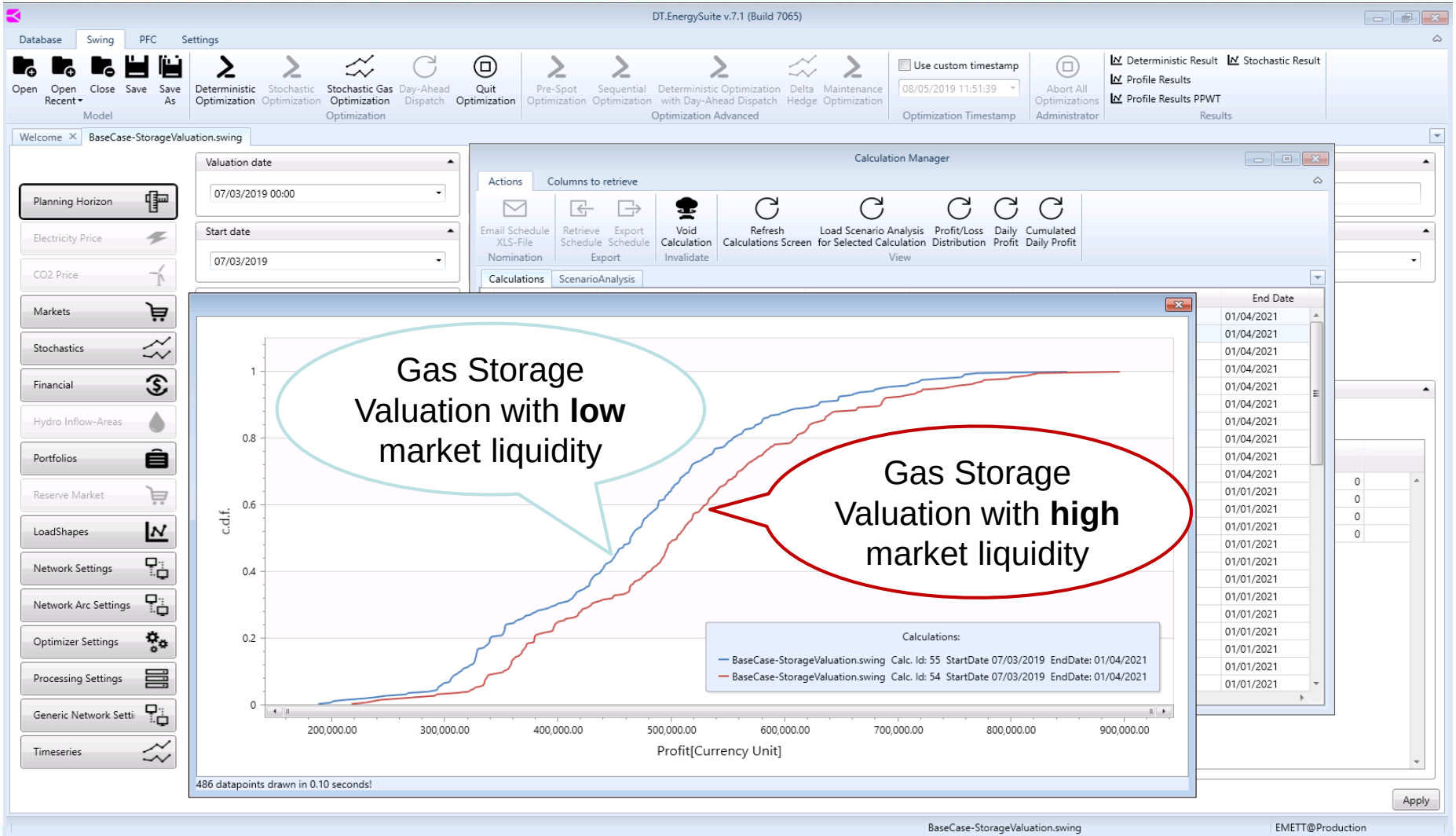
Profit distribution function

- Each scenario path in the tree represents one potential trading and operation strategy over time
- Each scenario path leads to a distinct overall profit
- Ascendingly sorted scenario profits provide the profit distribution function
- Risk analysis:
  - Min/Max Profit/Loss
  - PaR (Profit at Risk) with confidence level 97%, 90% etc.
  - Mean, Median, Standard Deviation
  - Curtosis





Profit distribution function

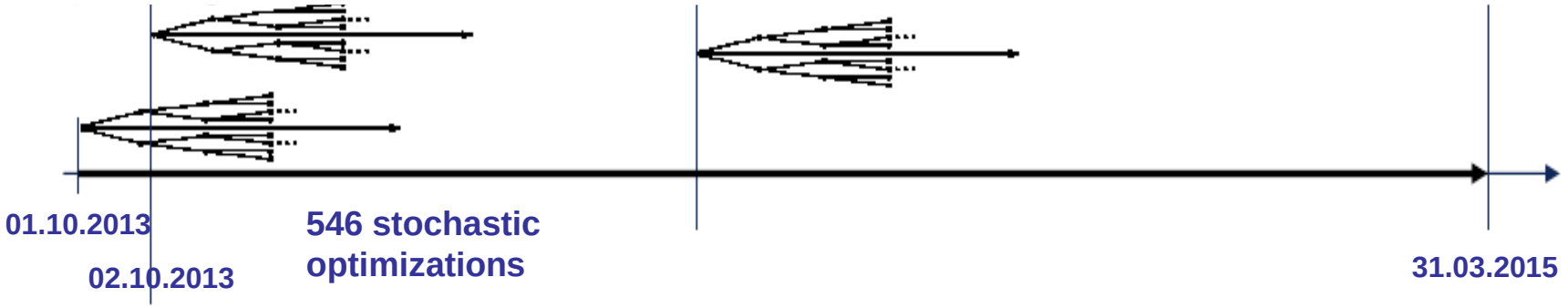


Backtesting of
Stochastic Optimization vs. Rolling Intrinsic
for a Gas Storage in Epe:

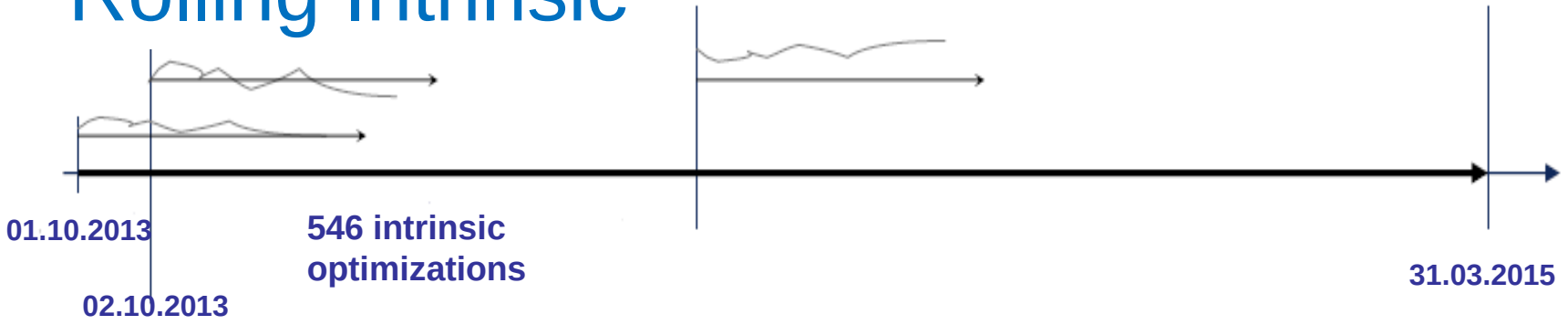
Rolling Optimization Storage Year 2014/2015
Rolling Optimization Storage Year 2015/2016
Rolling Optimization Storage Year 2016/2017

Deterministic vs. Stochastic Optimization:
Ex post Analysis: Rolling Optimization (Storage Year 14/15)

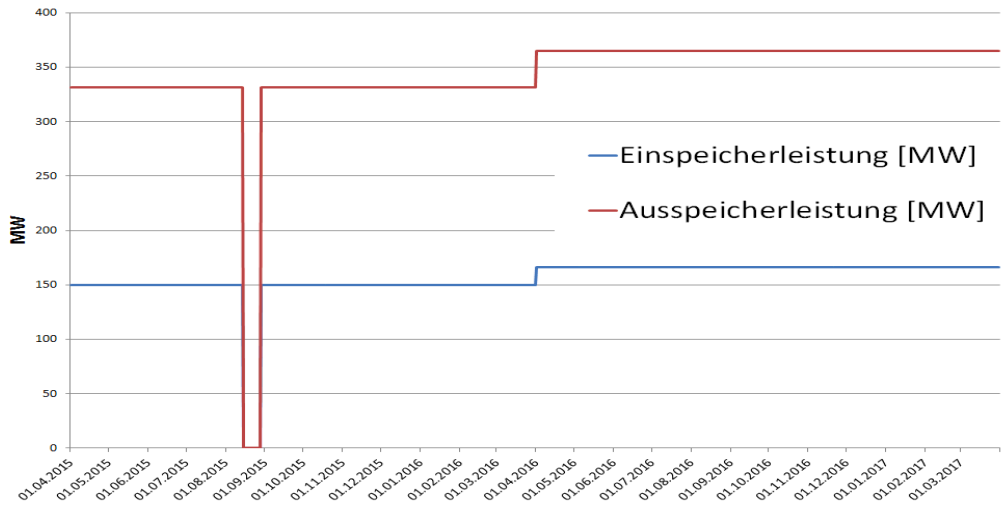
Rolling Stochastic

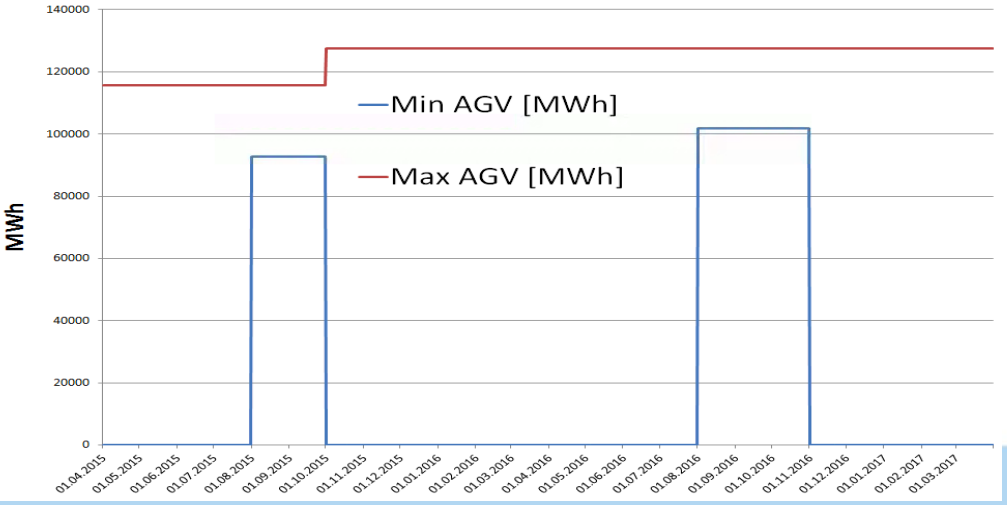


Rolling Intrinsic



Injection, Withdrawal Rates, Working gas Volume

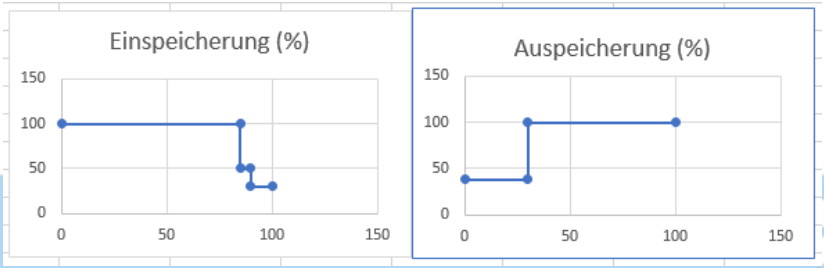




Inputs

- Target
  - Quantification of the added value of Stochastic Optimization for the Trianel Gas Storage
  - Consideration of all relevant constraints (Risk Capital, Storage Constraints)
  - Analysis of rolling optimization results for three storage years

- Basic Assumptions
  - Market: NCG
  - Financial constraint on open position: 212.000,- Euro (Daily valuation of open position against forward curve)
  - Storage Years
    - Storage Year 14/15: Trading period: 01.10.13-31.03.15 (physical operation 01.04.14-31-03-15)
    - Storage Year 15/16: Trading period : 01.10.14-31.03.16 (physical operation 01.04.15-31-03-16)
    - Storage Year 14/15: Trading period : 01.10.15-31.03.17 (physical operation 01.04.16-31-03-17)
  - Spreads:
    - Month ahead +/- 15 cent/MWh
    - 2 Month ahead, quarter ahead und later: +/- 25 cent/MWh
  - Storage characteristics:



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Inputs

- Risk constraints:
  - Long Positions in MW must not be greater than injection rate of storage
  - Short Positions in MW must not be greater than withdrawal rate of storage
  - Long Position in MWh must not greater than working gas volume
  - Short Position in MWh must not greater than working gas volume

- Further constraints:

  Constraint of open position:

  - 212.000 Euro <=

  Σ Long-Position * PFC - Σ Short-Position * PFC + storage volume * Day Ahead price

  <= + 212.000 Euro

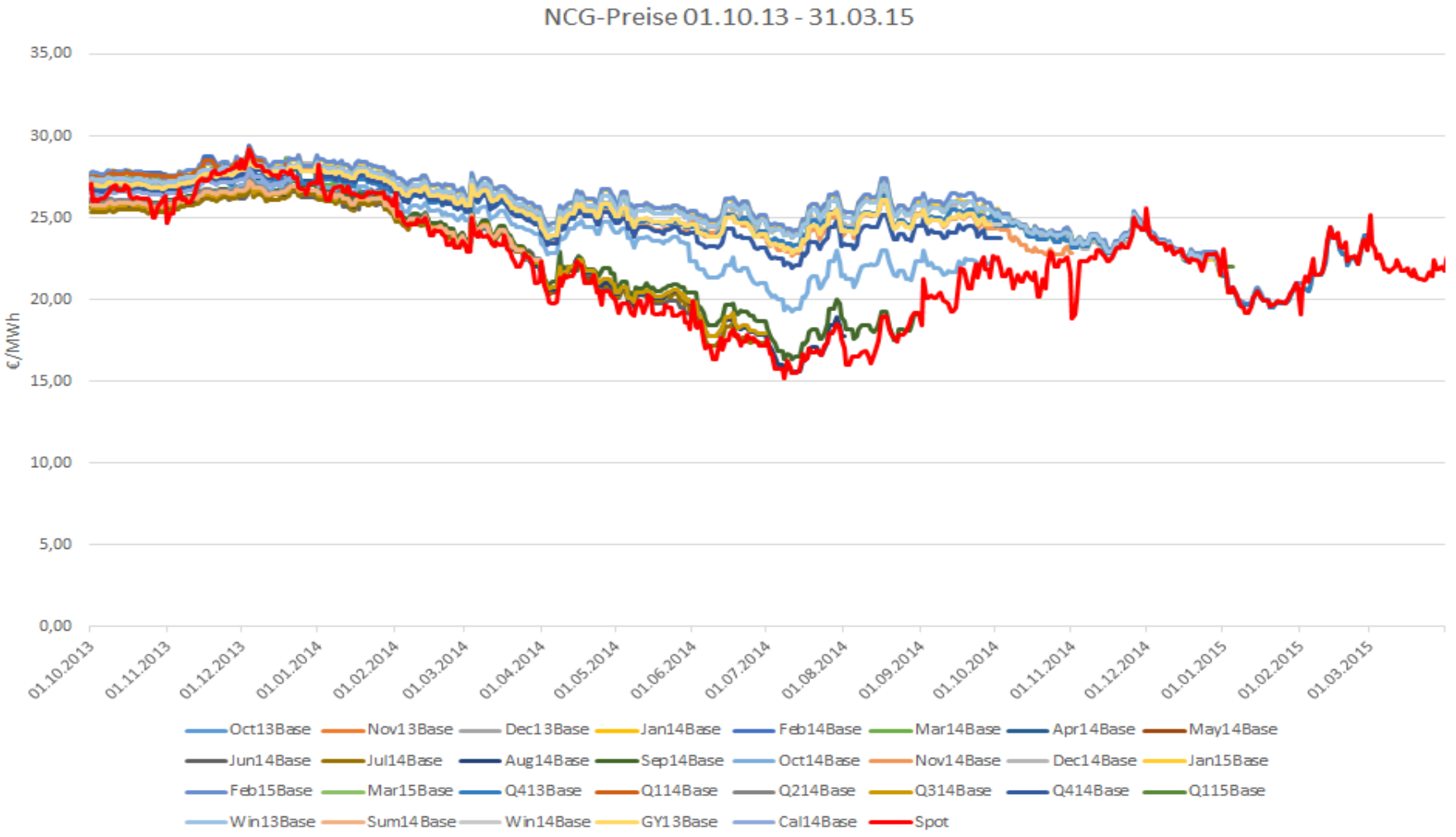
- Market liquidity assumption:
  - Month Ahead: 300 MW
  - Quarter Ahead, Season Ahead: 100 MW

Result summary

	Profit			Profit Increase			Specific Profit		
	14/15	15/16	16/17	14/15	15/16	16/17	14/15	15/16	16/17
Rolling Intrinsic	296.121 €	365.718 €	138.781 €				2,56 €/MWh	2,80 €/MWh	1,09 €/MWh
Rolling Stochastic	447.790 €	512.876 €	197.069 €	51,22%	44,03%	42,32%	3, 87€/MWh	4,09 €/MWh	1,55 €/MWh
Risk Captial	212.000 €	212.000 €	212.000 €						

Stochastic Optimization
generates significant added value over rolling intrinsic.

Storage Year 14/15 Evolution of Prices



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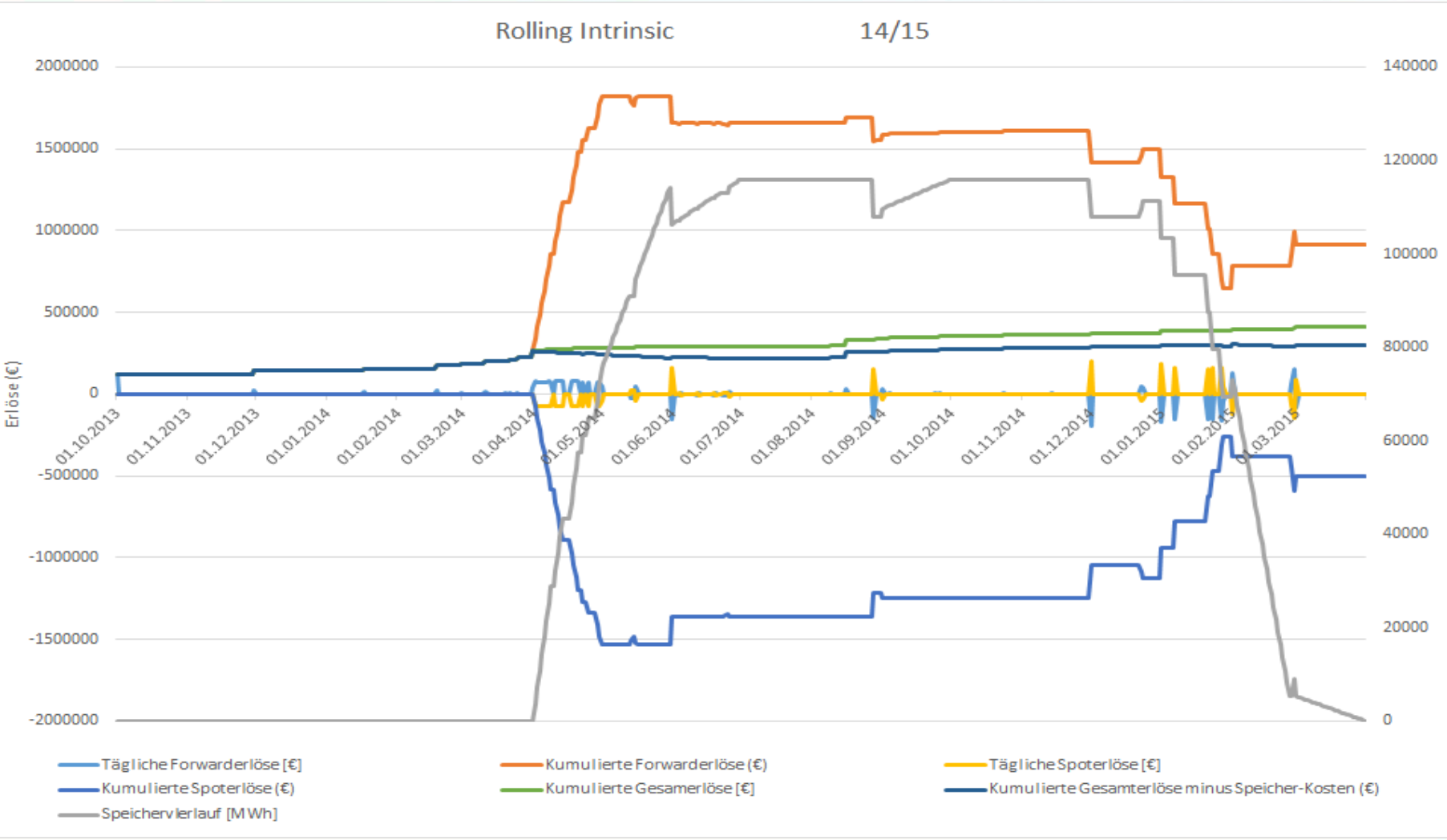
Storage year 14/15 rolling intrinsic result



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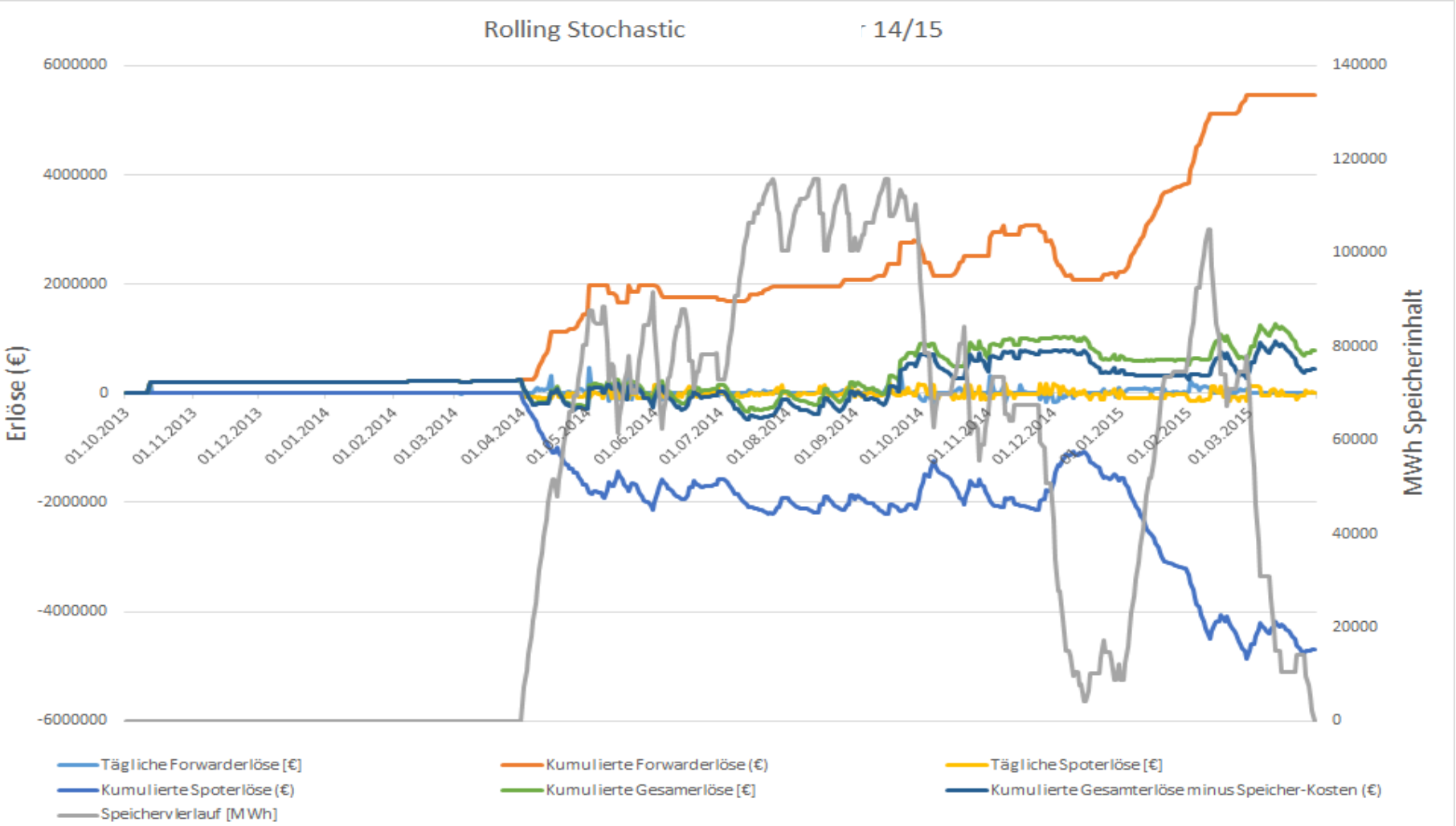
Storage year 14/15 rolling stochatic result



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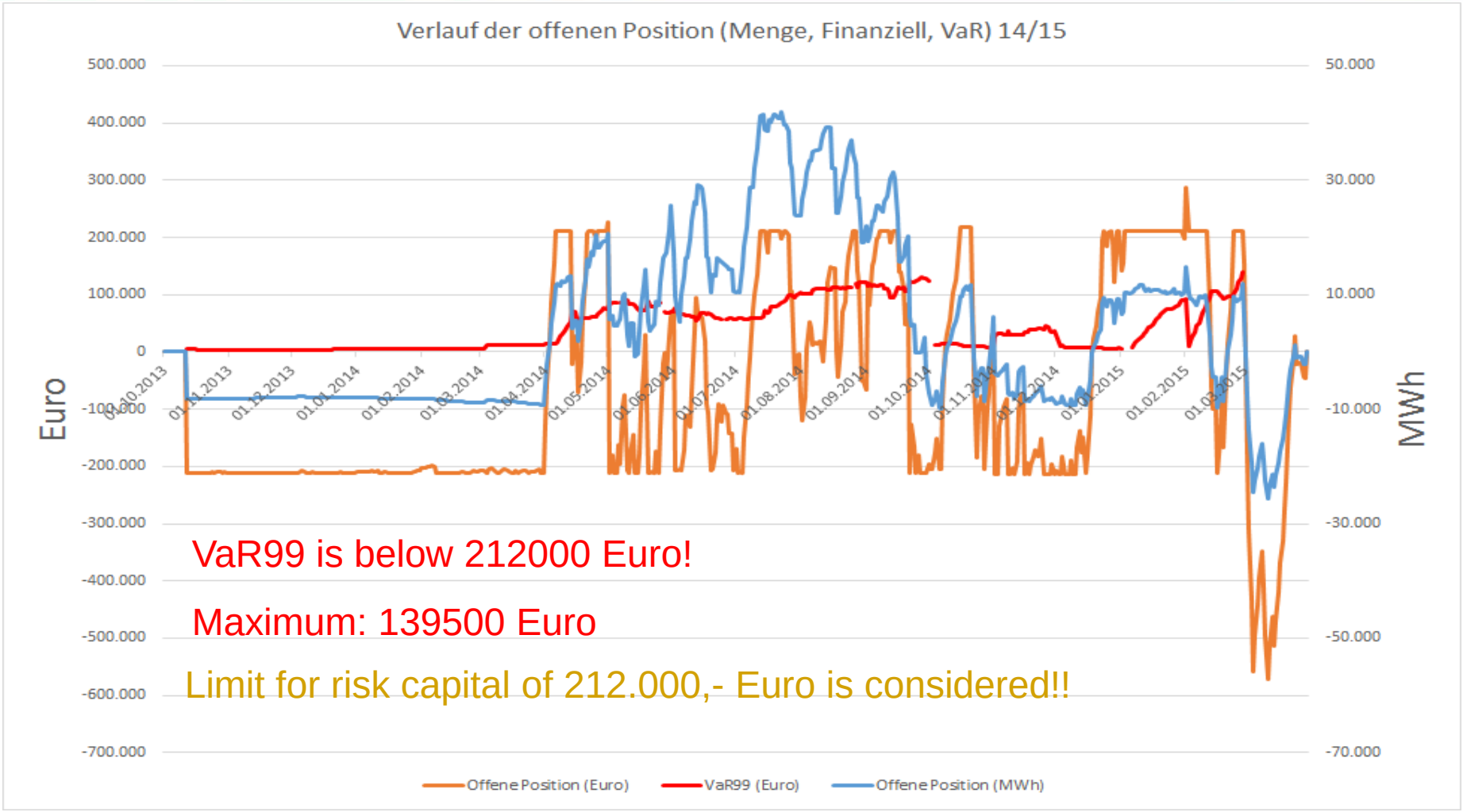
Storage year 14/15 rolling stochastic result
Evolution of Value-at-Risk



VaR99 is below 212000 Euro!

Maximum: 139500 Euro

Limit for risk capital of 212.000,- Euro is considered!!

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Conclusions

- Conventional Back-to-Back-Trading does not yield sufficient revenues anymore in today‘s gas markets
- Asset Backed Trading with open positions involves risk
- Scenario Tree based Stochastic Optimization provides decision support under consideration of particular risk constraints (physical, financial)
- Scenario Tree yields significantly higher results over rolling intrinsic
- Higher risk affinity provides higher profits in average
- DTrees has introduced stochastic optimization for asset backed trading decision support at various utilities in Germany, Austria and the UK

Contact us …

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