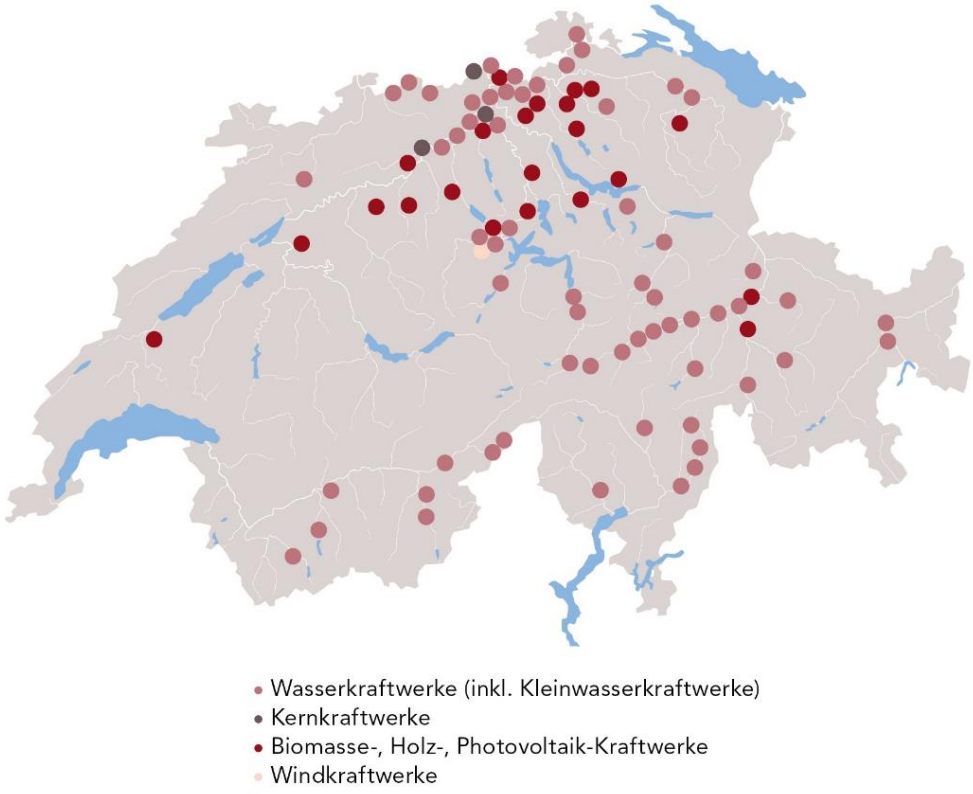
Multi-market trading in Switzerland using SHOP

13. March, Frank Böttcher

Contents

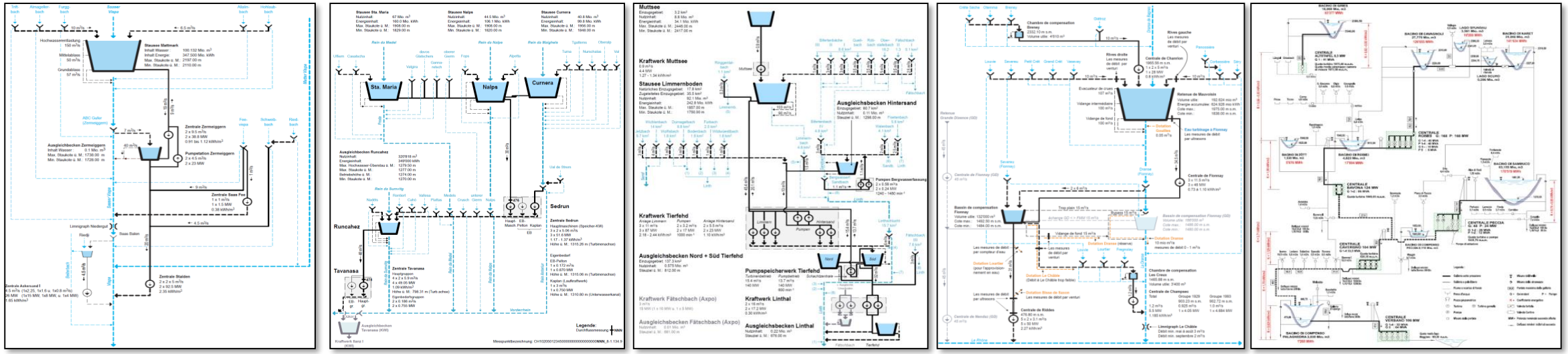
- Brief Axpo Introduction
- Daily Optimization Set-up & Reserve Market CH
- Opportunity Cost Calculation using Matlab & SHOP
- Version / Feature Benchmarking using automated set-up
- Outlook / 2nd Example

Introducing Axpo Solutions



Introducing Axpo Solutions

- 22 water courses: 25 Reservoirs & 32 balancing basins
- 54 stations: 130 turbines, 6 pumps, 17 pump-turbines & 4 variable-speed pump-turbines



Pool of diverse watercourses

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Hydroplant Optimization: Modelling

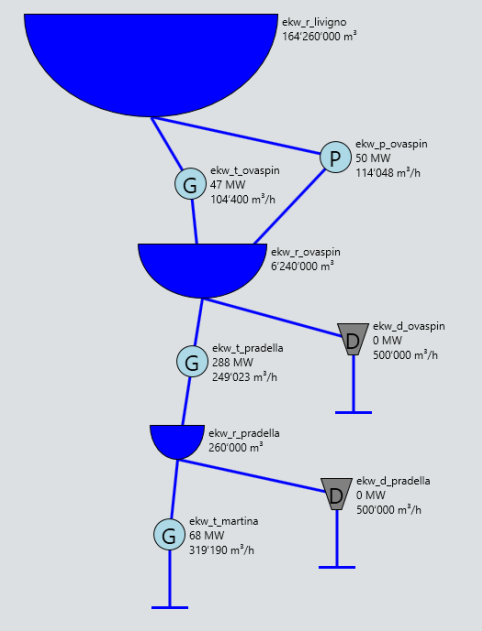
Combined short- & long-term optimization

Forward Market → Spot Market → ID Market

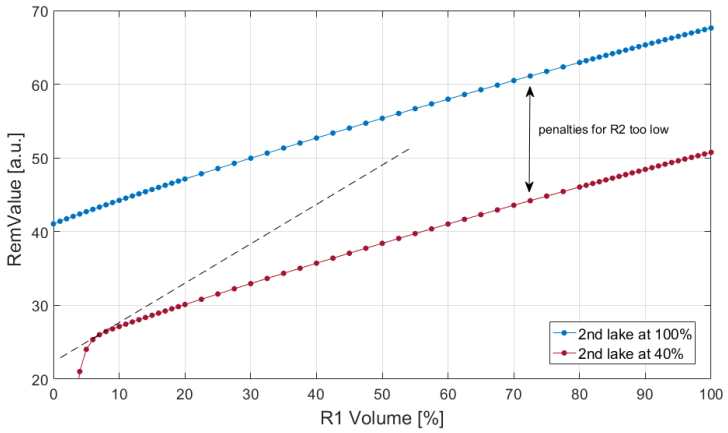
← Ancillary Services →

- Inflows
- PFC
- Availability / REMIT
- Lake Restrictions
- Stochastics
- Real time

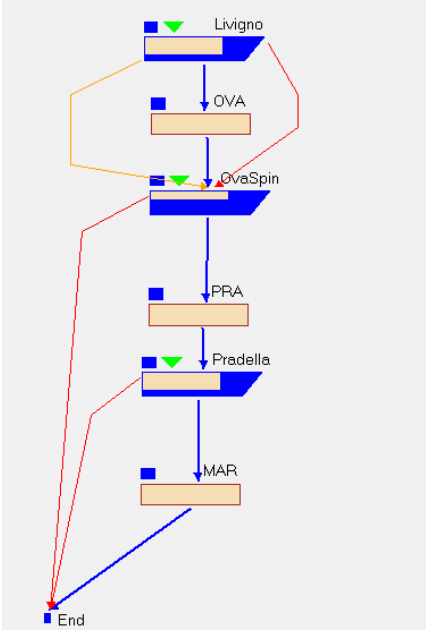
Long-Term [D+21 until Y+1]



Coupling via RemValue (cut-files)

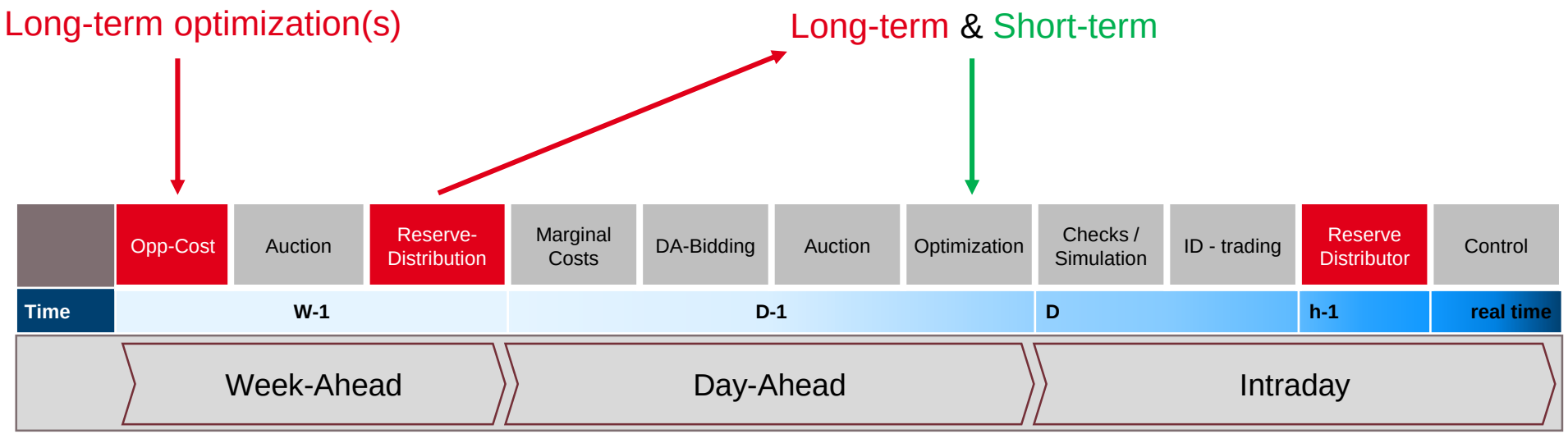


Short-Term [D+1 until D+21]



Hydroplant Optimization: Process

Example:
Spinning Reserves (aFRR), weekly, asymmetric blocks, bidding on Tuesdays for following week



Reserve Market in Switzerland

Weekly auctions on Tuesday → Will become **daily** in the near future

- pay-as-bid
- FCR ± 74MW
- aFRR +400MW, -400MW

Two principle tasks:

- **Decision support for bidding of reserves: Reserve Opportunity Cost Calculation**

- Providing reserve obligations with least costs: Intraday Reserve Re-Distribution

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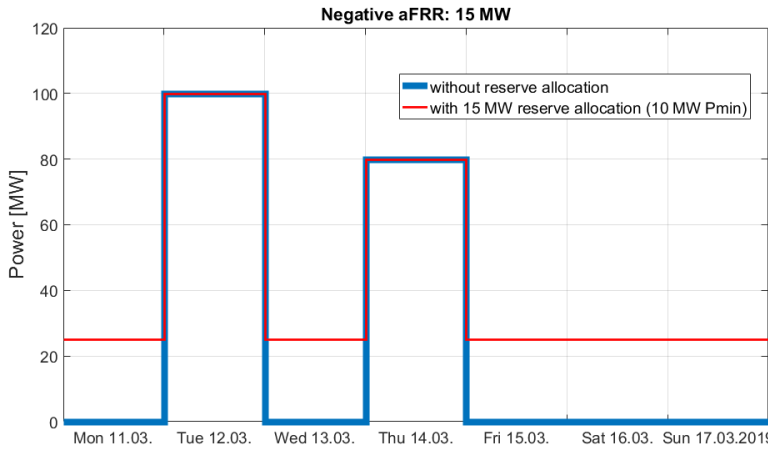
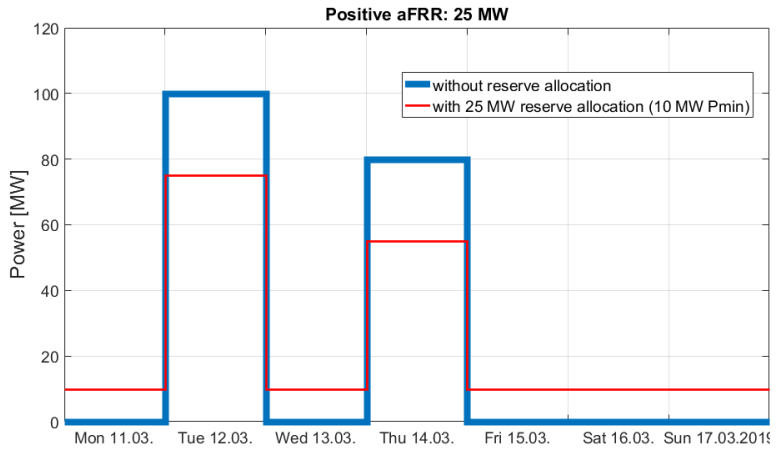
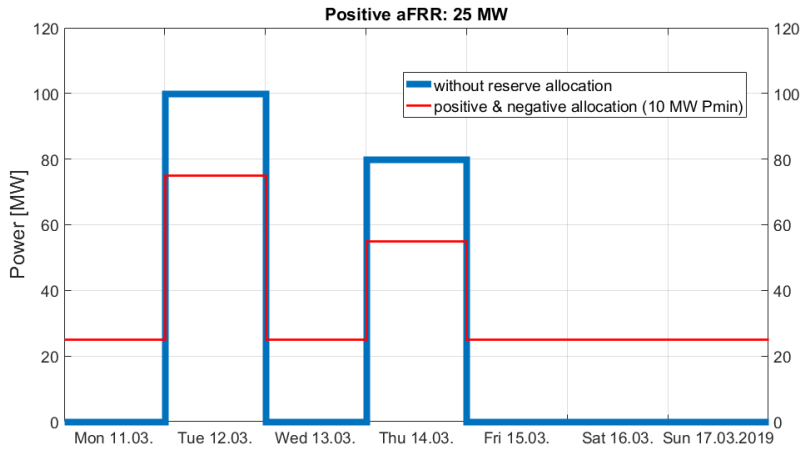
Opportunity Cost Calculation





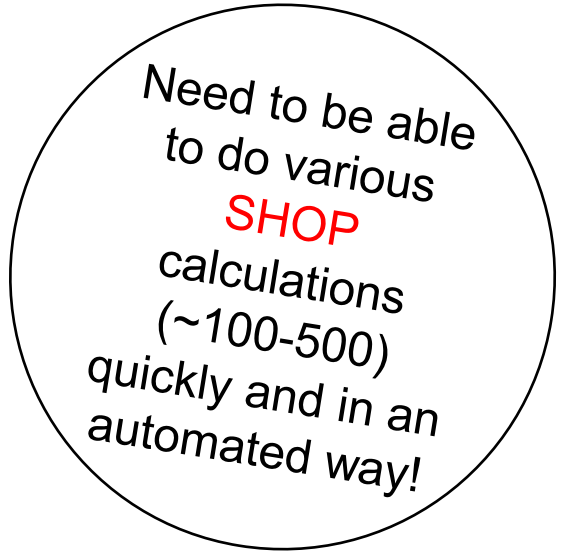


Opportunity Costs (OC) = (STrev1 - STrev2) + (RemVal1 – RemVal2)

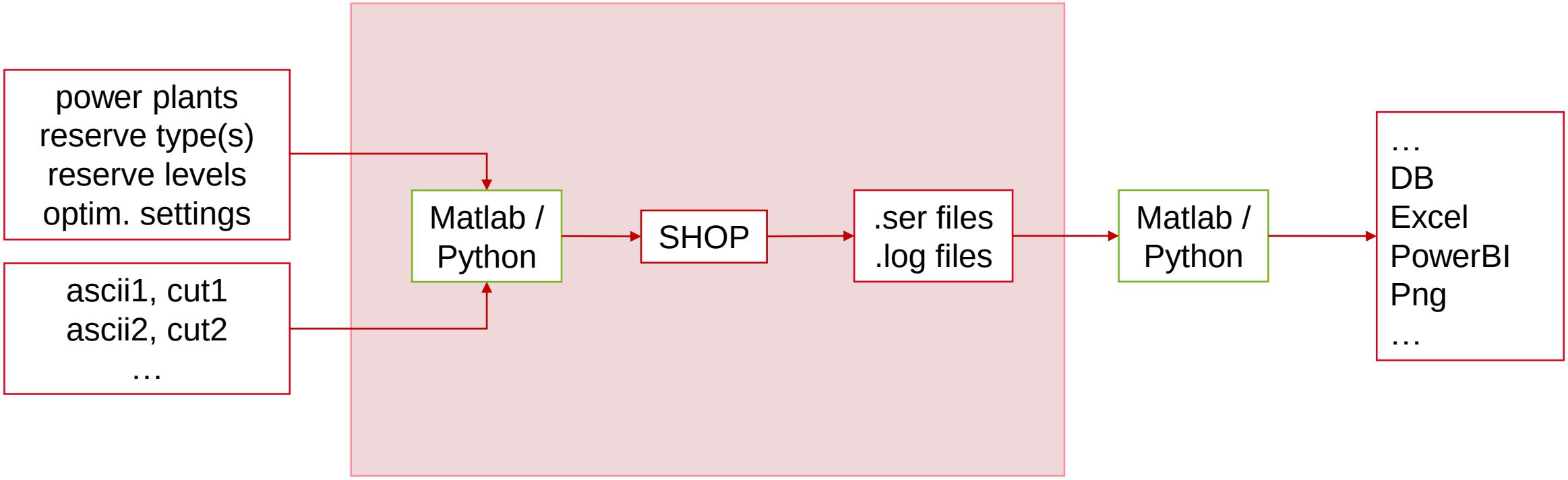
Inputs for OC Calculation

What is the opportunity cost…

- for individual plant / per pool
- for different reserve power levels (up & down & combined)
- for different times of the year (season)
- for different price / inflow scenarios (“what-if”)
- for different ramping settings (pool in particular)
- etc.



OC Calculation Set-up



Outputs of OC Calculation

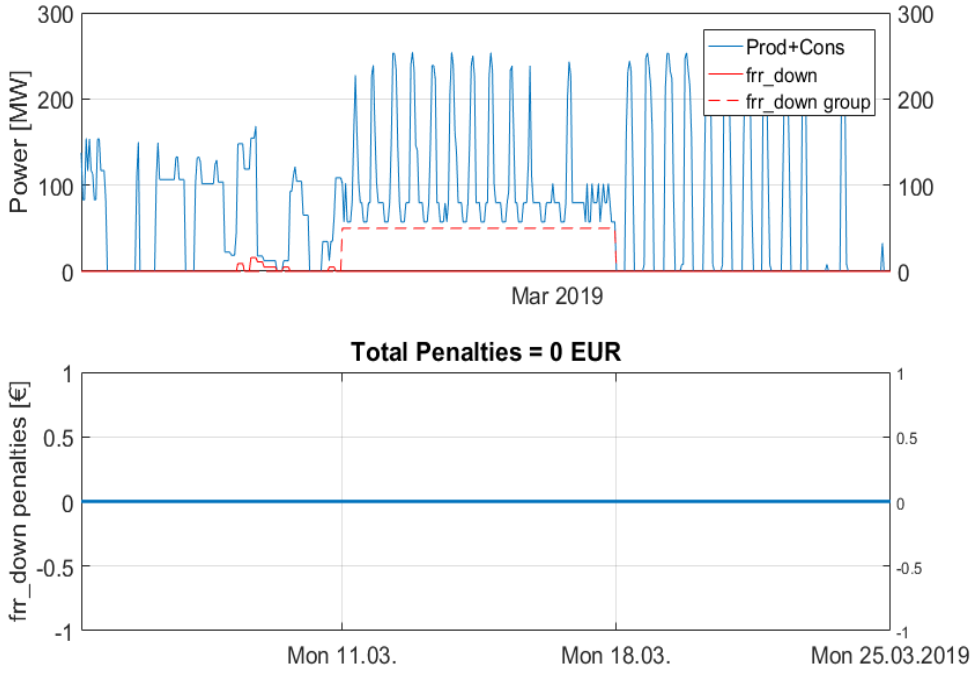
- Archiving of results (seasonality detection / prediction)
- Information about unit contributions / ramping

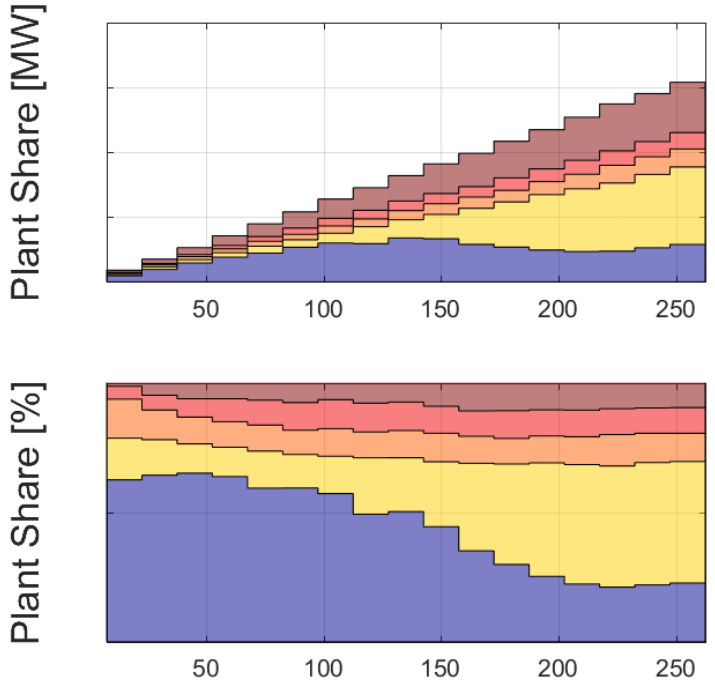
Plausibility checks / Analysis

- Information about penalties
- Volume-price OC curve for individual assets – comparison to pool

Bidding / Auction Pricing

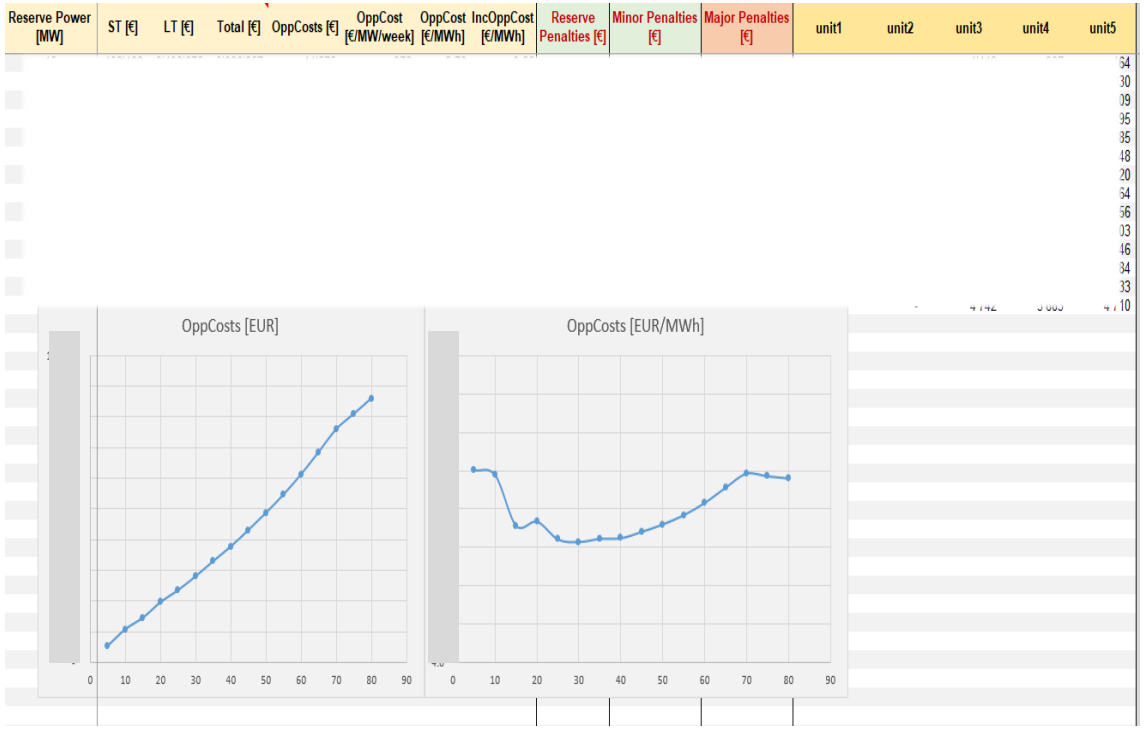
Results – Plausibility Checks



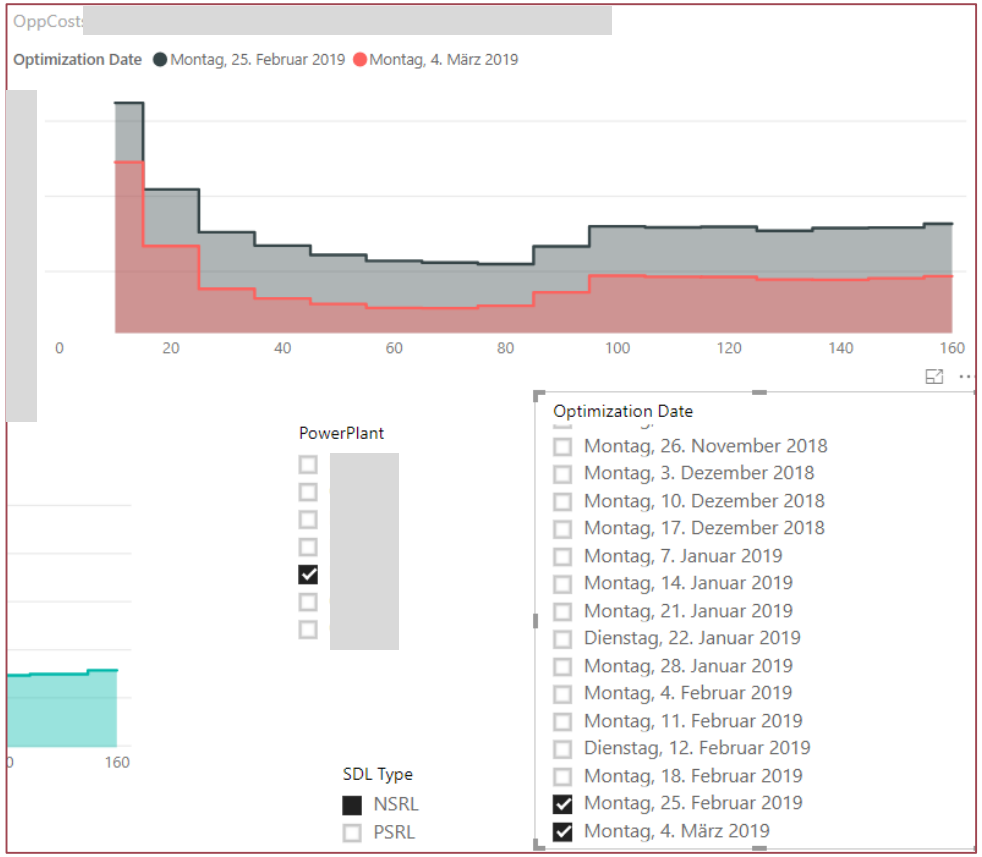


Results – Auction Bidding

Excel



Power BI



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Analyzing Version & Feature Changes

Idea:

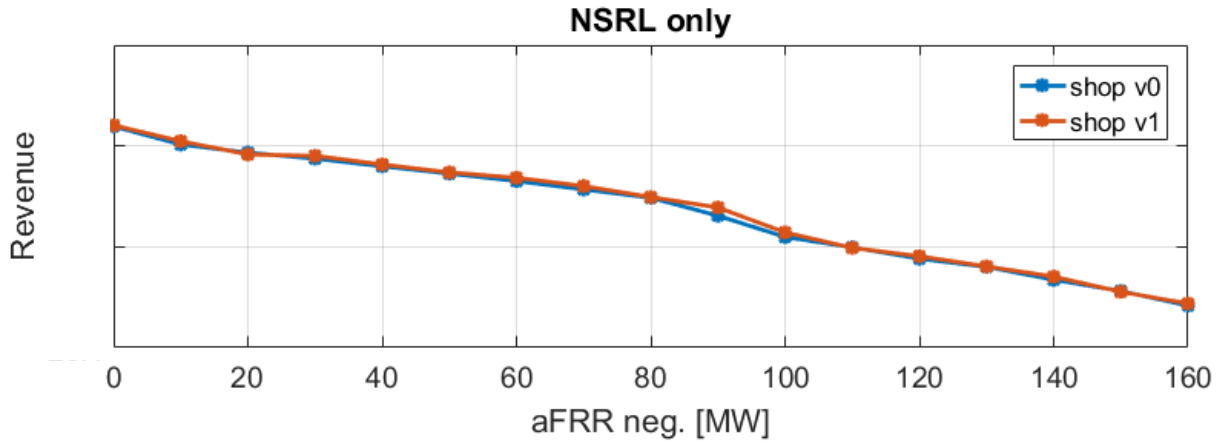
Use the multi-run set-up as described before with two different SHOP versions and study the outcome

The OC calculation is an interesting test-case for that because OC are based on small value differences, i.e. small changes in

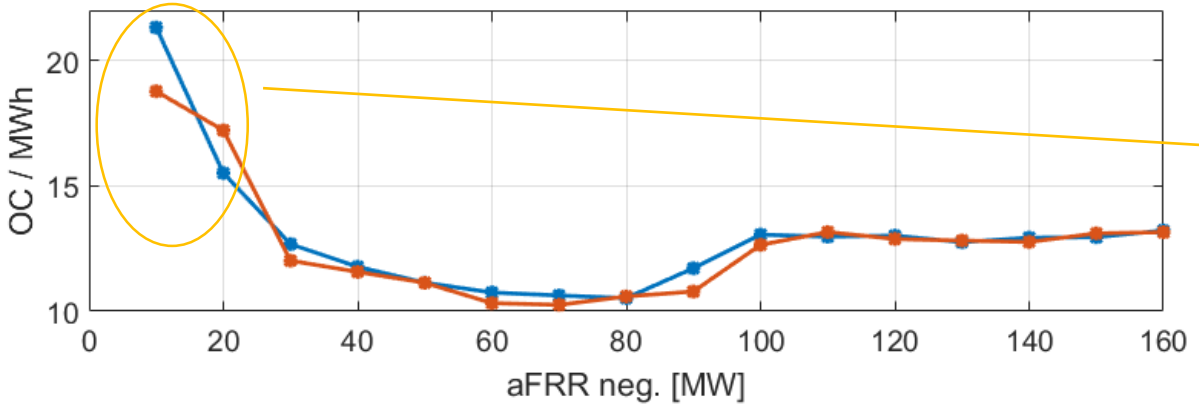
- Remaining Values
- Short-term dispatch (different efficiency handling for instance)

will immediately be visible in the final OC value.

SHOP Version Impact [aFRR neg.]

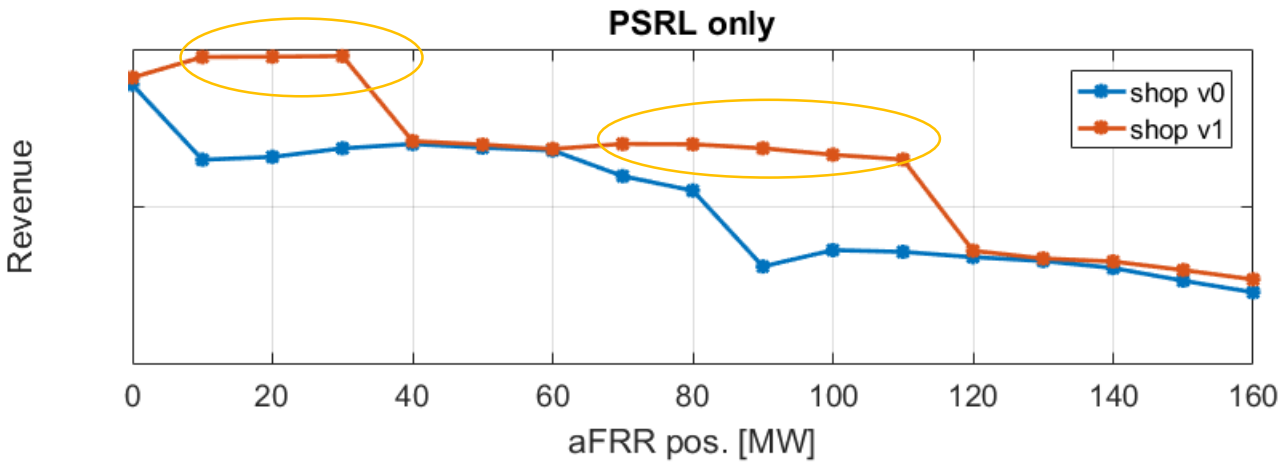


~ 350k

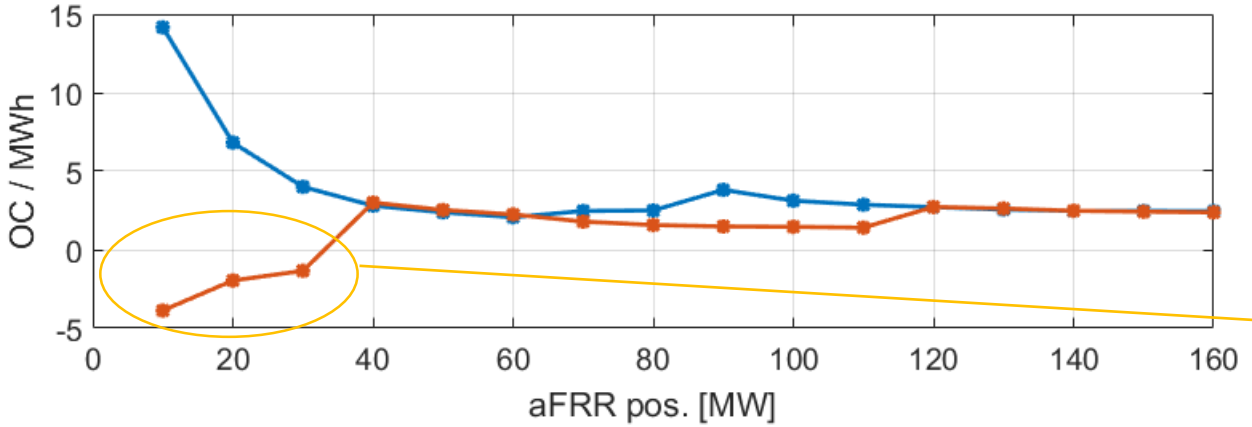


Sensitive, small value differences divided by varying reserve power

SHOP Version Impact [aFRR pos.]



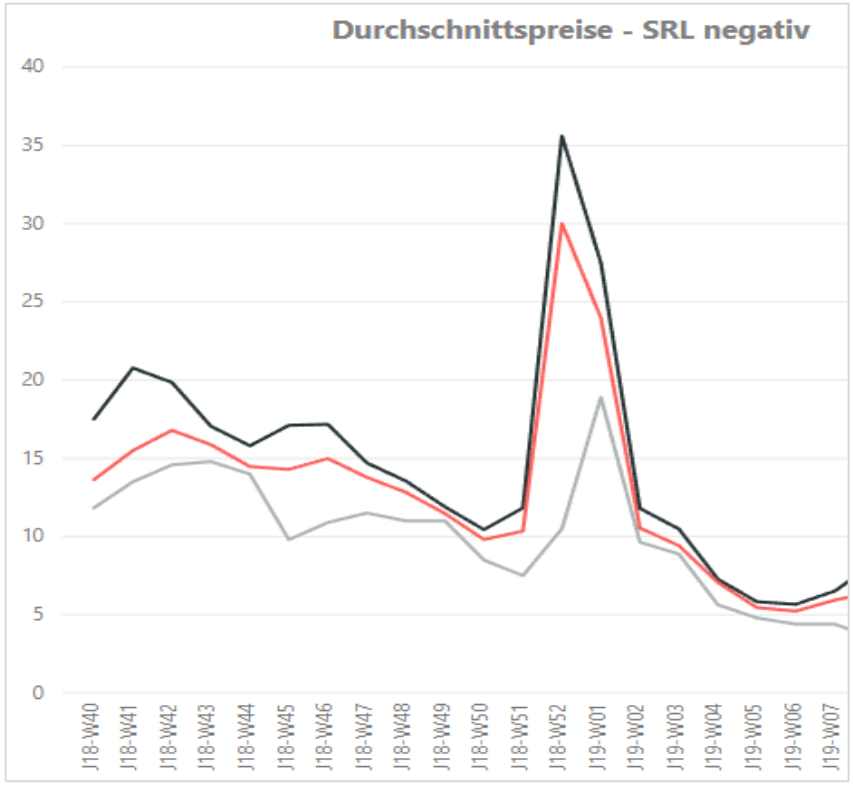
~ 70k

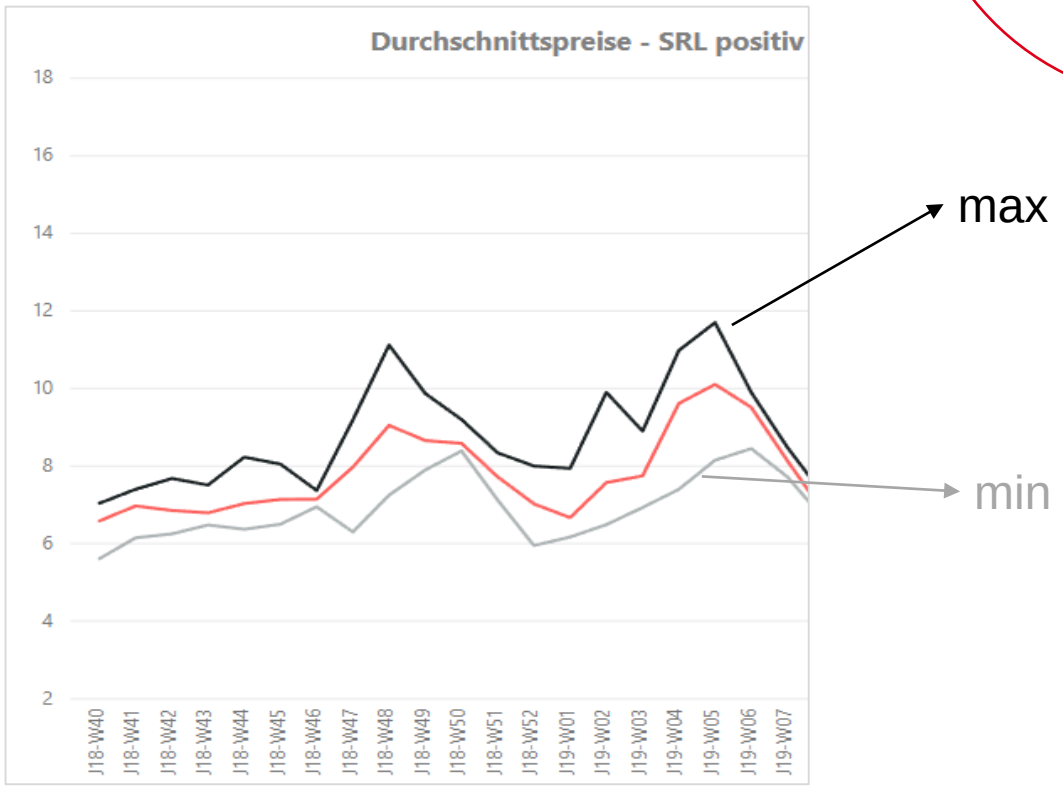


Even negative OC values

Historic FRR Prices in Switzerland

Rather small variation of realized offers, exact price per volume matters!





Summary & Outlook

- Using SHOP via Matlab/Python adds a lot of flexibility to daily calculations and analysis
- OC calculation / bidding-matrix as a real in-use examples
- Potential improvements: Pyshop (“Matshop”?) in order to minimize the input-output operations via files and to facilitate data / model modifications

Thanks / Takk