R&D SHORT-TERM SCHEDULING

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User Meeting, Trondheim 11/5-2017

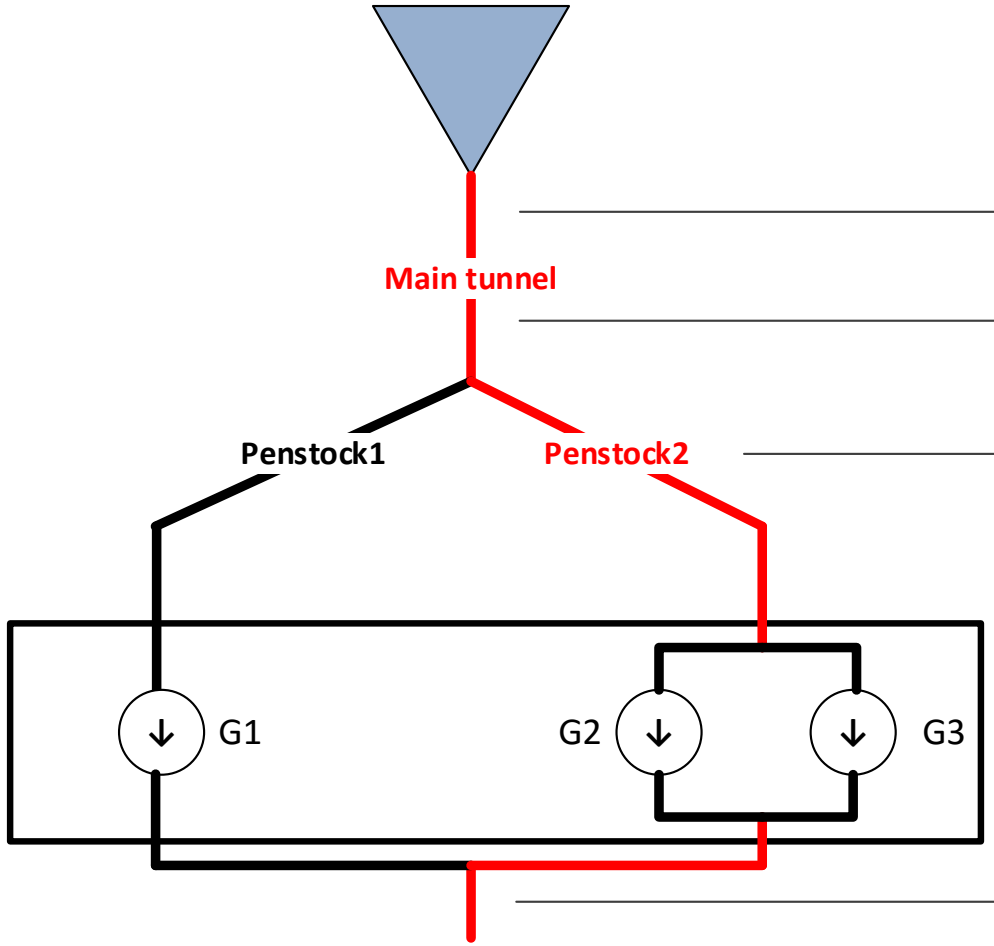
Separate presentations

- Pressure links
- Multimarket extensions
- Best Profit in Intraday

Head calculations

- Power loss in tunnels and penstocks
- Head loss in intakes
- Head loss from tailrace
- Head loss from bypass
- Power head optimization

Head loss calculations



Intake loss $\Delta h_1 = f_1(q_{sum})$

Main tunnel loss $\Delta h_2 = \alpha_m q_{sum}^2$

Penstock loss $\Delta h_3 = \alpha_p q_{pen}^2$

Tailrace loss $\Delta h_4 = f_4(q_{sum})$

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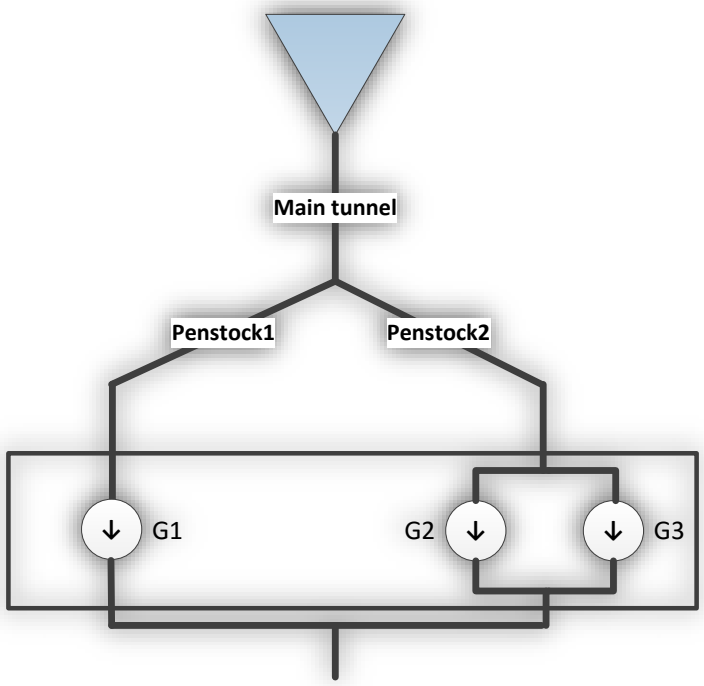
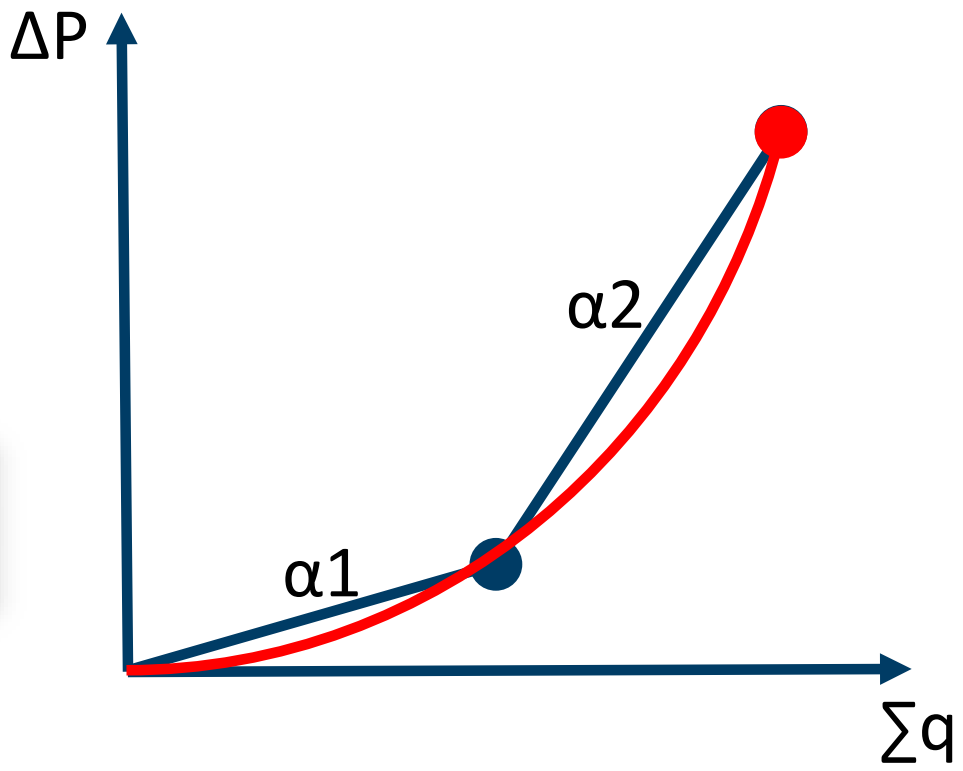
Power loss in tunnels and penstocks





- Power loss is a cubic function of discharge
- Linearization of multiple units' discharge
- Dynamic segmentation
- Number of segments 2/10

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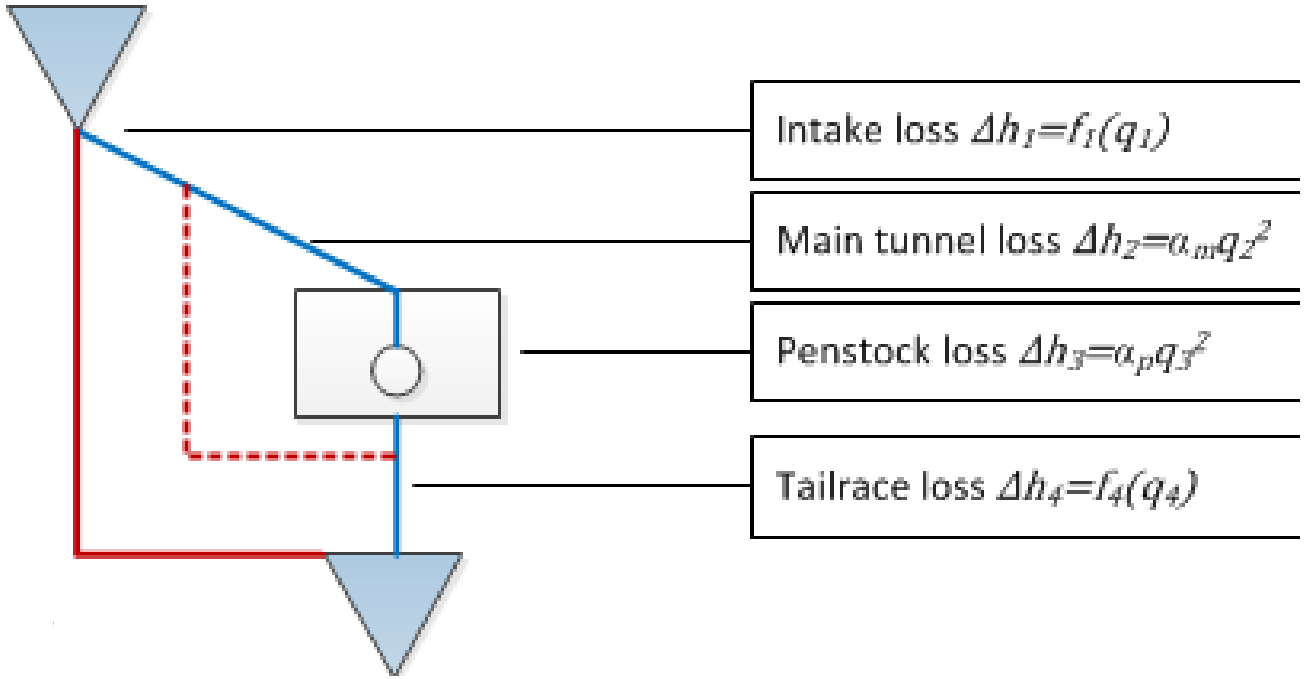
Intake- and tailrace-loss

```
PLANT intake_loss <plant_name>
# Id Number     Ref   npkt  x_unit     y_unit
  1  1          830   3     M3/S       METER
# x        y
0.000      0.00
30.000     0.15
35.000     0.20

PLANT intake_loss <plant_name>
# Id Number     Ref   npkt  x_unit     y_unit
  1  1          860   3     M3/S       METER
# x        y
0.000      0.00
30.000     0.20
35.000     0.25
```



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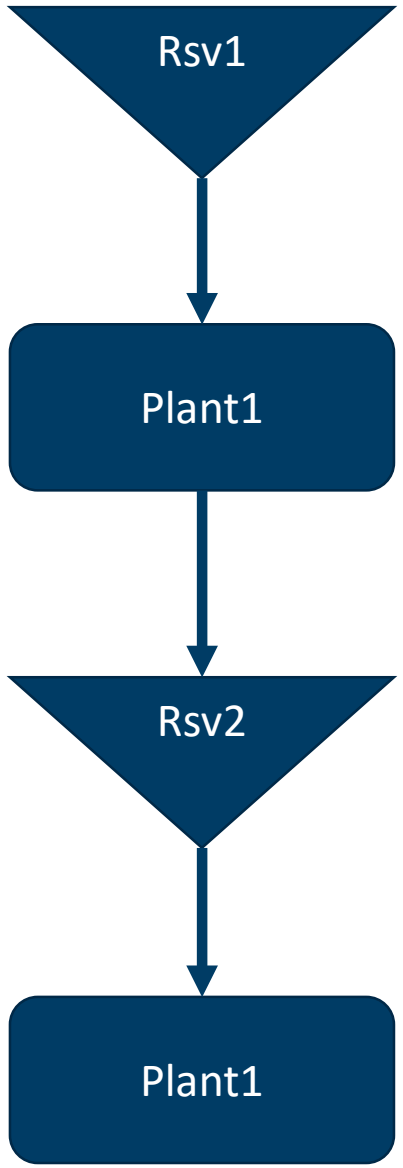
Power head optimization

$$p = \eta(h, q) \cdot g \cdot h(v, q) \cdot q$$

$$p_{min} \leq p \leq p_{max}$$

$$q_{min}(h(v, q)) \leq q \leq q_{max}(h(v, q))$$



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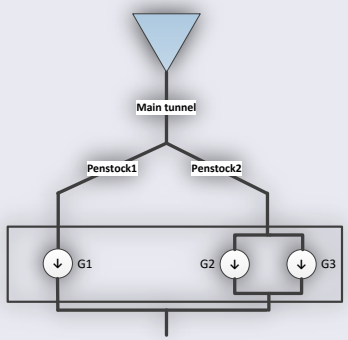
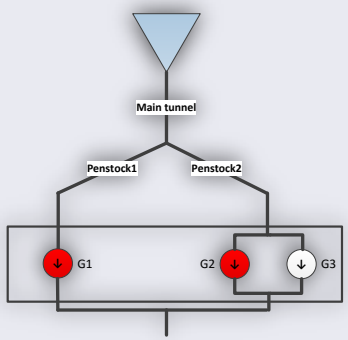
Other development

- Ownership scaling
- Reserve clustering and symmetric reserves
- Build on generator level
- Discharge groups
- Creek intake inflow scaling
- Linear start-up
- Junction gate optimization
- Discharge limits

Build on generator level

Full mode (set code /full)	**LP model**	**MIP model** (mip_flag/universal_mip as input data)
	• Built on PLANT level	• Built on UNIT level
Incremental mode (set code /incr)	**LP model**	**LP model** (reserve/gen discharge cost is used)
	• Built on PLANT level	• Built on UNIT level

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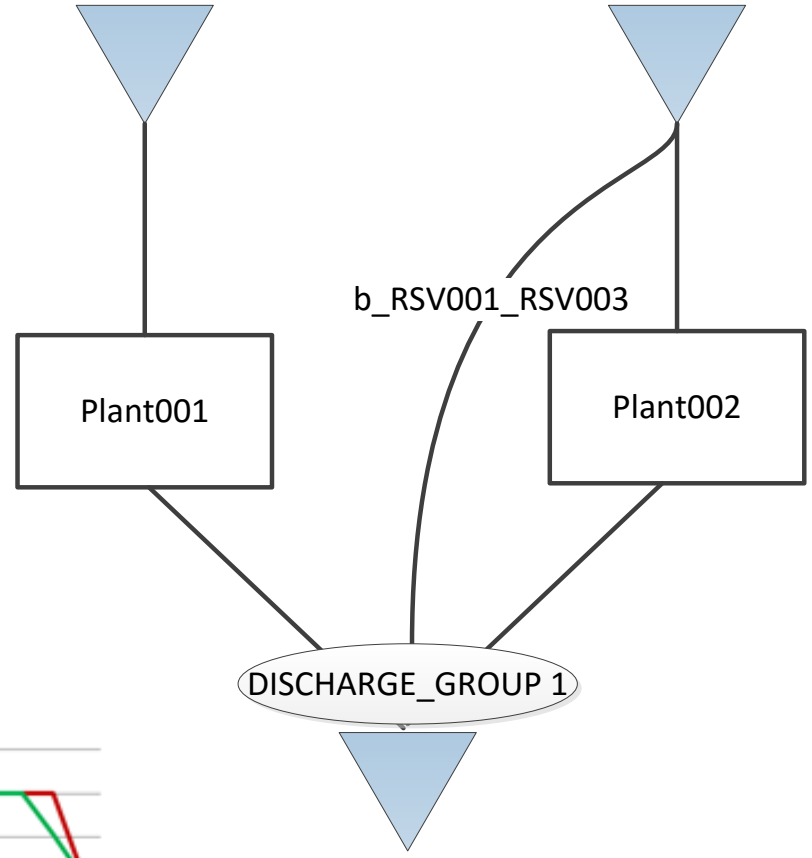
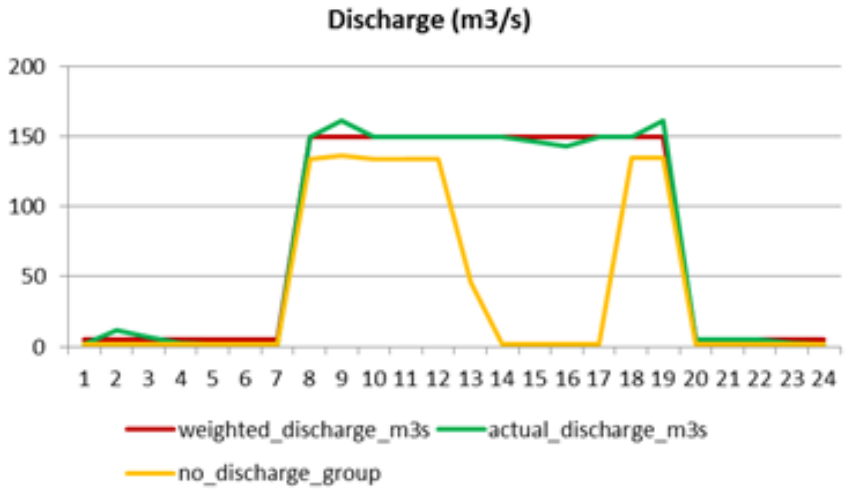
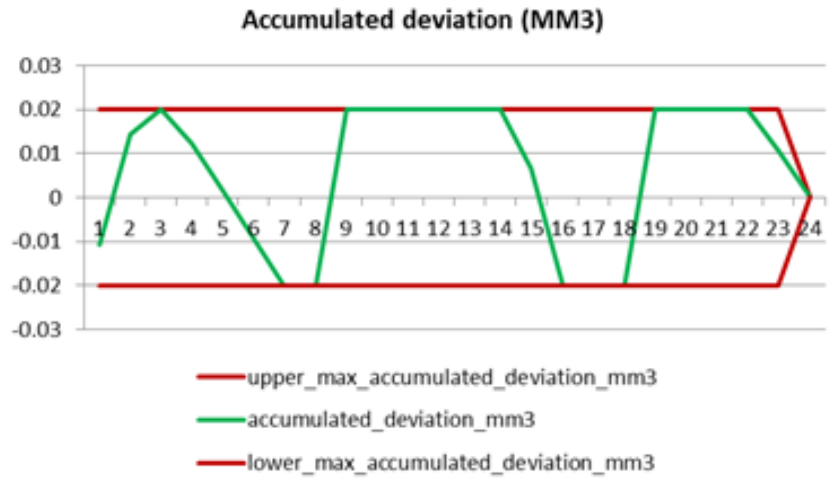
Discharge groups

- Weighted discharge with accumulated deviation limits







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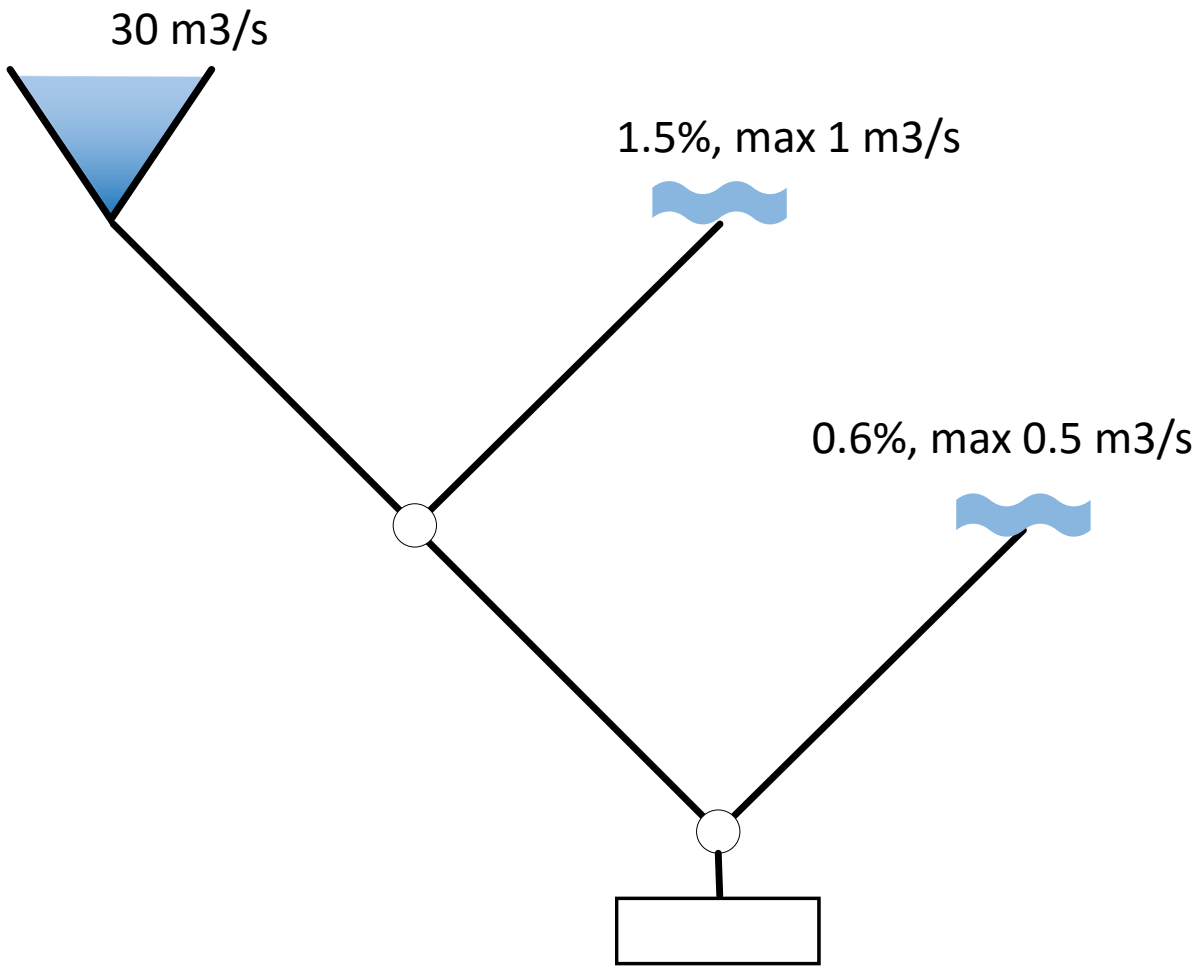
Creek intake inflow scaling

- Inflow into the reservoir is given as a time series
- Each creek intake can have a reference reservoir with a scale factor and max capacity



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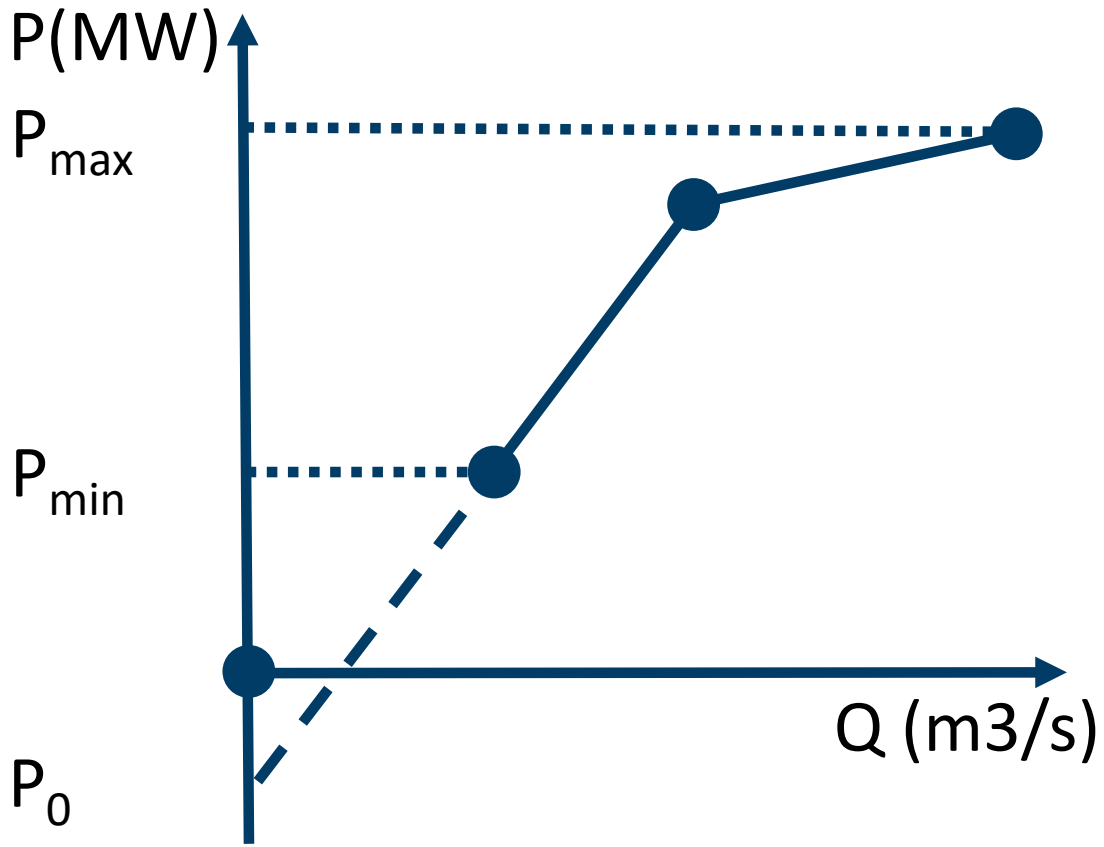
Linear start-up: P-Q curve



MIP model

$$p = P_0 \cdot \gamma_t + \sum_{seg} \frac{dP}{dQ}_{seg} \cdot q_{seg}$$

$$p \geq P_{min} \cdot \gamma_t$$

$$p \leq P_{max} \cdot \gamma_t$$

$$\gamma_t \in \{0, 1\}$$

$$\gamma_{t-1} - \gamma_t + start\_var_t \geq 0$$

$$\gamma_t - \gamma_{t-1} + stop\_var_t \geq 0$$

In objective function, add

$$+ start\_cost_t \cdot start\_var_t$$
$$+ stop\_cost_t \cdot stop\_var_t$$

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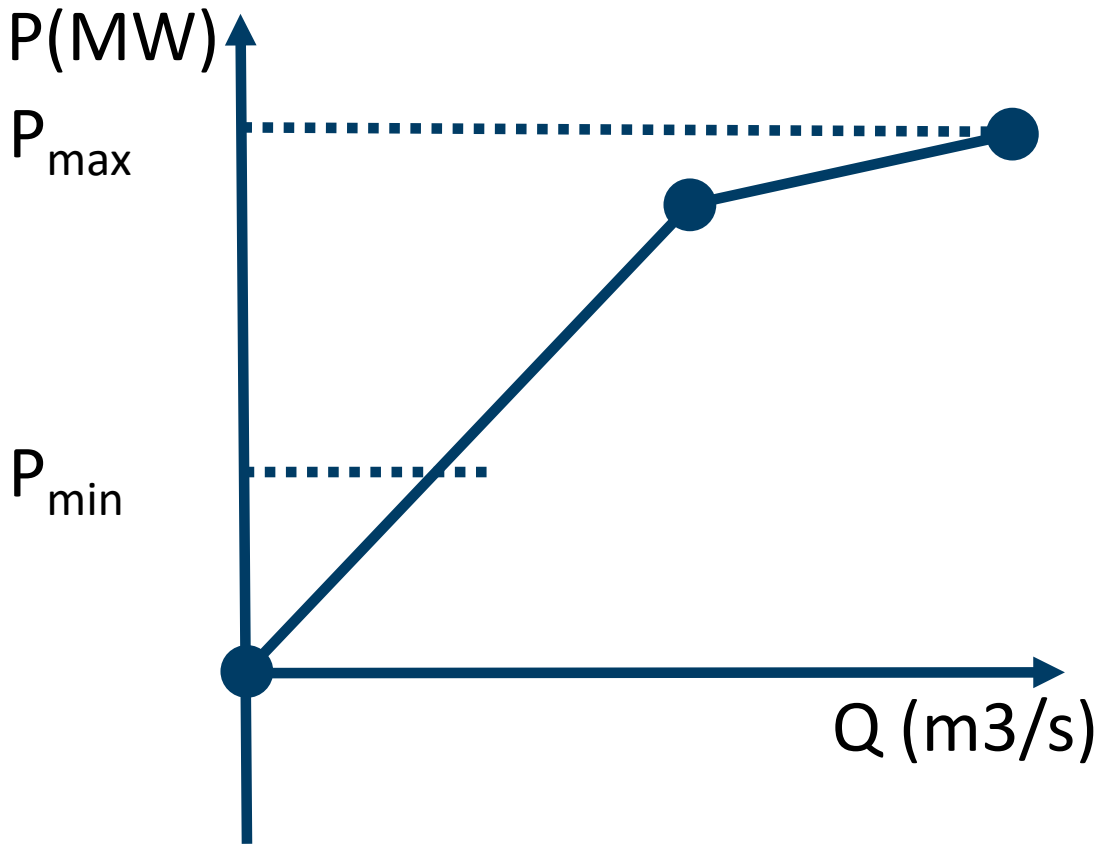
Linear start-up: P-Q curve



LP model with linear start-up

$$p = \cancel{P_0 \cdot \gamma_t} + \sum_{seg} \frac{dP}{dQ}_{seg} \cdot q_{seg}$$

$$p \geq P_{min} \cdot \gamma_t$$

$$p \leq P_{max} \cdot \gamma_t$$

$$\cancel{\gamma_t \in \{0,1\}} \quad 0 \leq \gamma_t \leq 1$$

$$\gamma_{t-1} - \gamma_t + start\_var_t \geq 0$$

$$\gamma_t - \gamma_{t-1} + stop\_var_t \geq 0$$

In objective function, add

$$+ start\_cost_t \cdot start\_var_t$$
$$+ stop\_cost_t \cdot stop\_var_t$$

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Linear start-up: Results

Earlier results showed an improvement of 0.67 for stochastic rather than multiscenario deterministic bidding

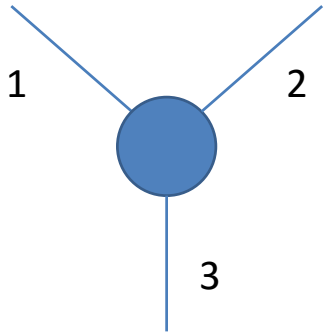
	MILP	LIN	Difference (%)
Revenue	9,356,940	9,352,317	0.055
Penalty	17,267	17,162	-0.2259
Start-up cost	71,590	72,162	0.7990
Cost of water used	750,425	746,079	-0.5791
Total objective	8,527,659	8,516,848	0.0095
Obtained average price	23.47	23.47	0.0006
Time	38 min	32 min	15.79

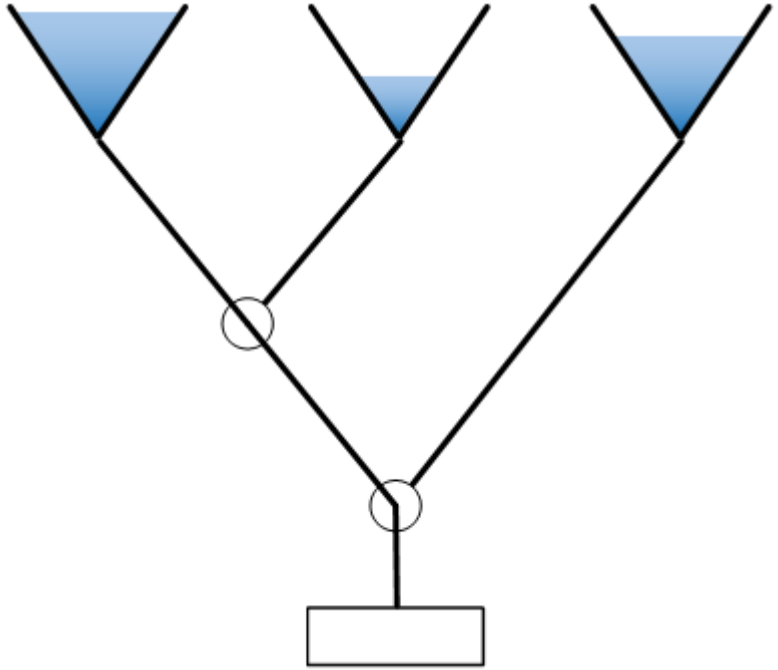
These results are from simulation model

Calculation time: Above results are from the simulation model, where most of the time is spent generating and reducing scenario trees. In SHARM, calculation time is more than 25 times faster when using linear rather than binary startups.

New R&D – Junction gate optimization

State	Comment
A	The tunnel is closed
B	The tunnel is open
C	The tunnel is either fully open or fully closed
D	The tunnel can be partially closed





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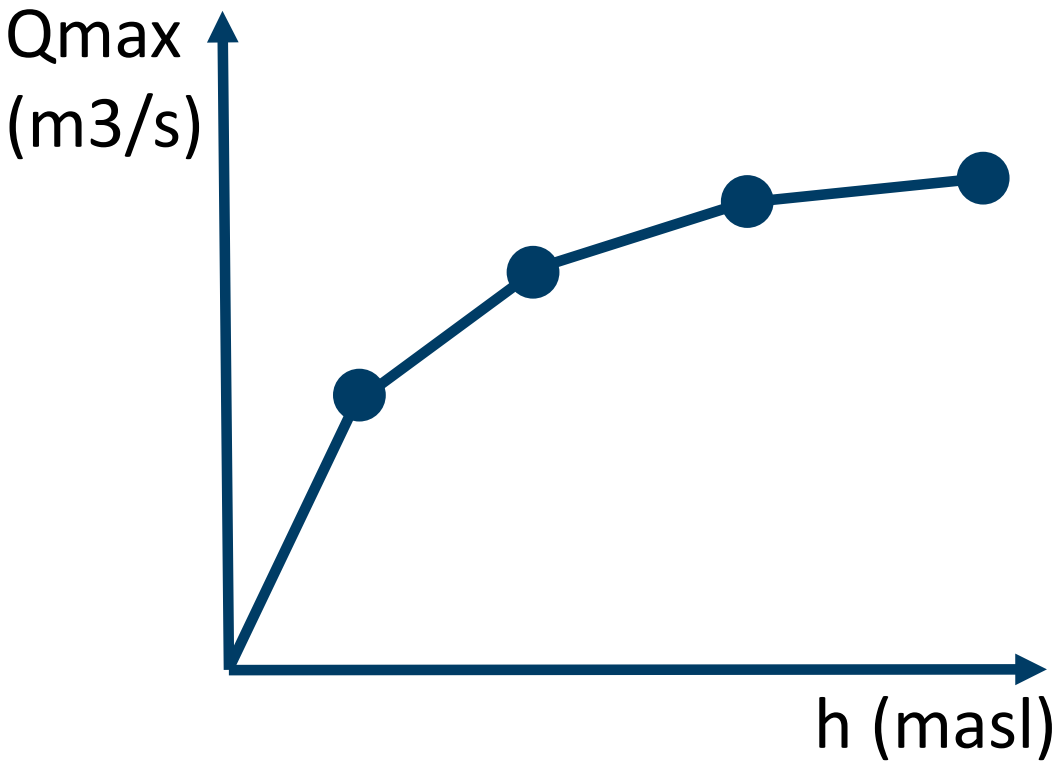
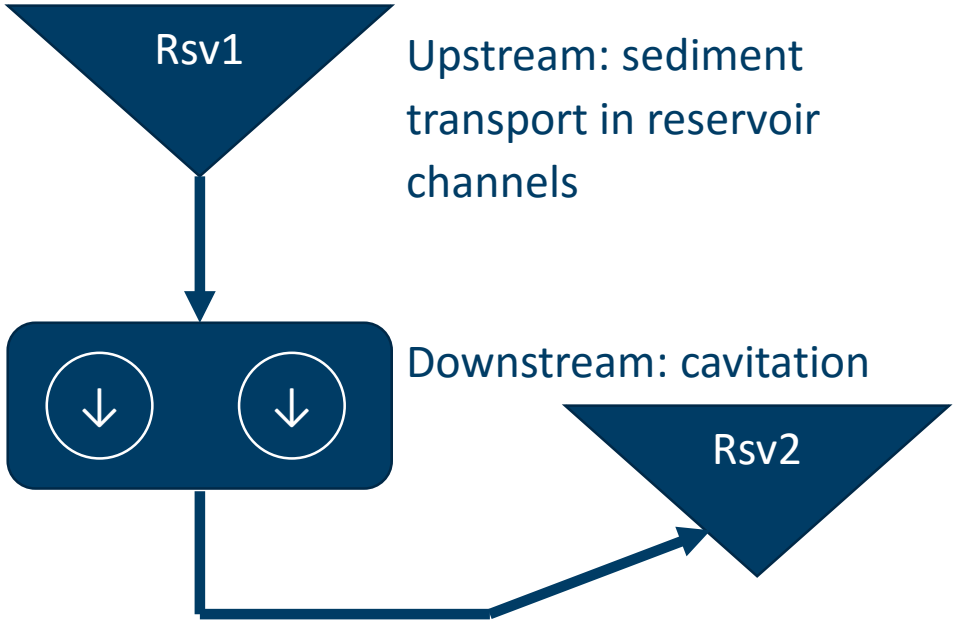
New project: Discharge limits





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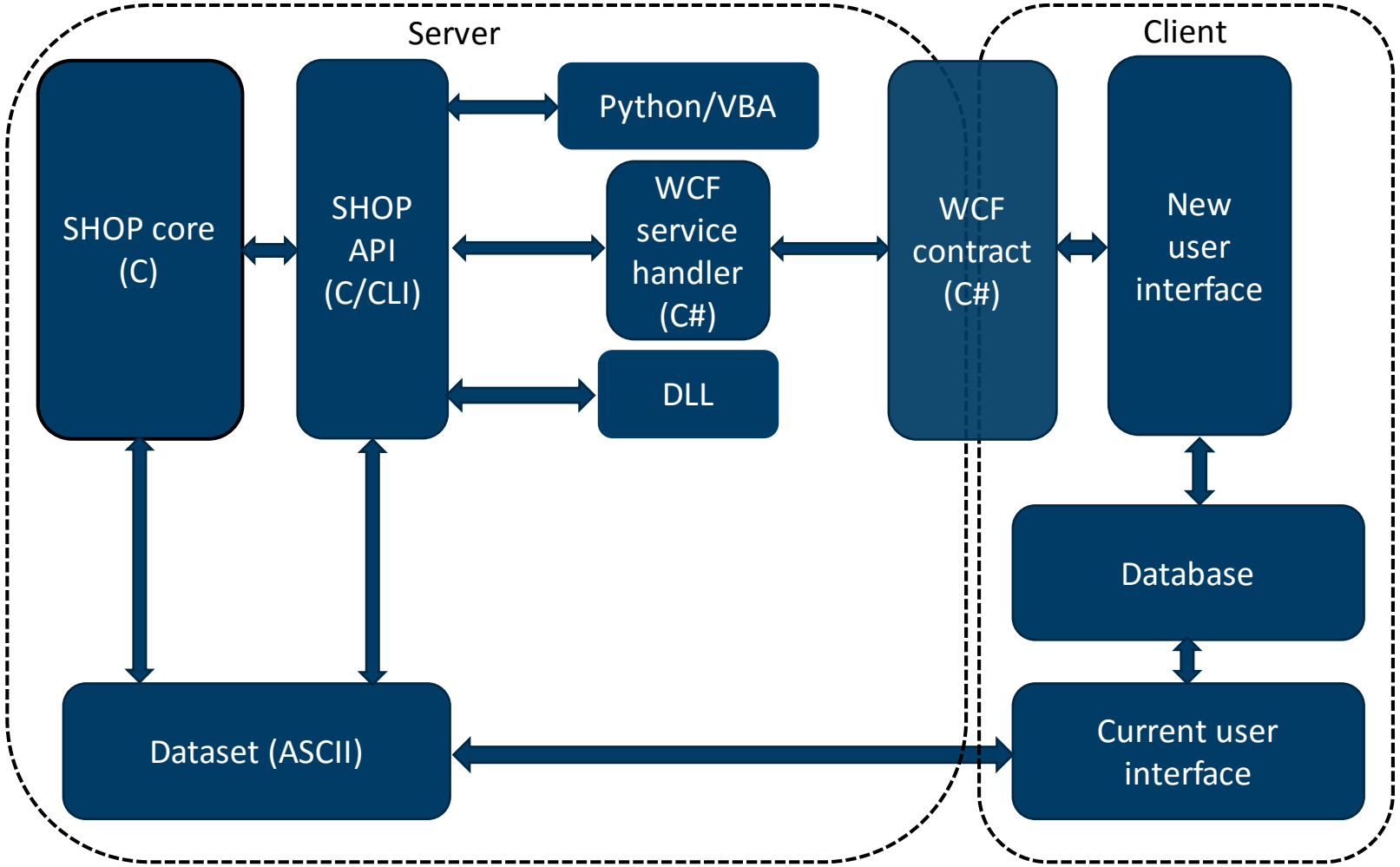
API


Server
Client
SHOP core (C)
SHOP API (C/CLI)
Python/VBA
WCF service handler (C#)
DLL
WCF contract (C#)
New user interface
Database
Current user interface
Dataset (ASCII)

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