NEWS IN SHORT-TERM SCHEDULING

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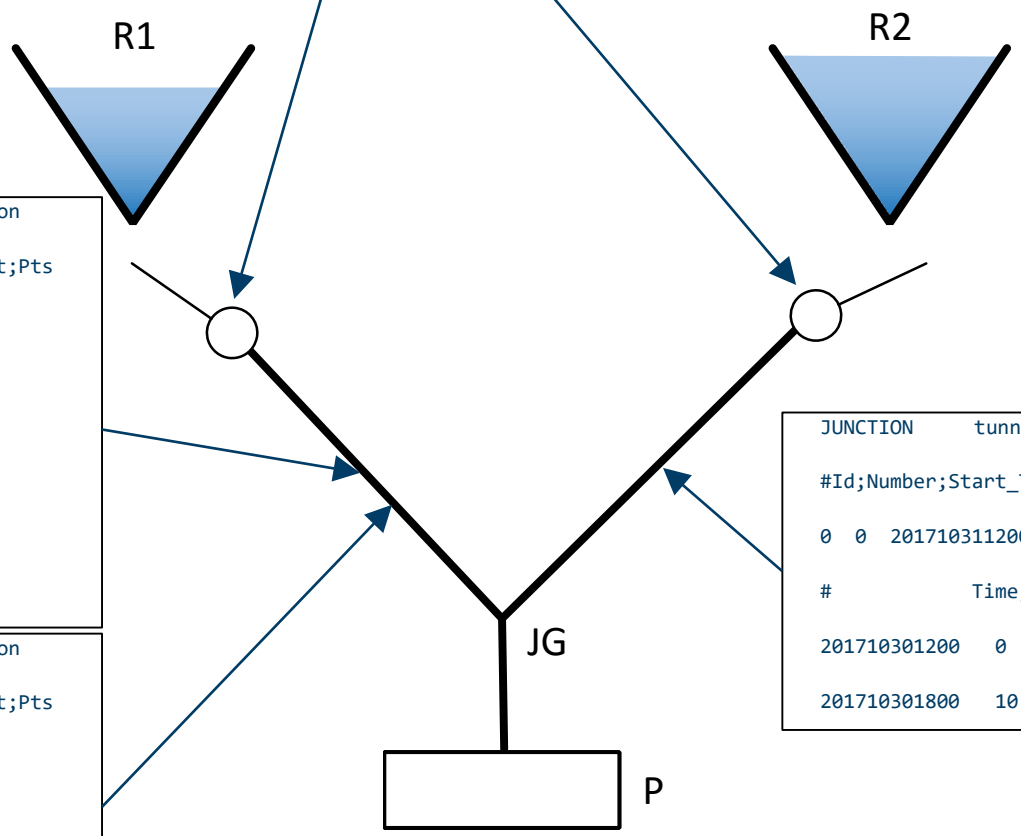
Production planning User meeting

Hell, March 14, 2019

Junction gate optimization

- JUNCTION tunnel_1_close_time MyJunction 360
- JUNCTION tunnel_2_close_time MyJunction 180
- JUNCTION tunnel_1_open_time MyJunction 120
- JUNCTION tunnel_2_open_time MyJunction 240




```
JUNCTION     tunnel_1_optimization_flag       MyJunction
#Id;Number;Start_Time;Time_unit;Period;Data_type;Y_unit;Pts
0  0  201710311200  MINUTE  525600  -1  NO_UNIT  4
#            Time;      f(t)
201710301200   0  #Closed
201710301800   1  #Open
201710310000   2  #Either fully open or closed
201710310600   3  #Throttling allowed
```

```
JUNCTION     tunnel_1_switch_cost             MyJunction
#Id;Number;Start_Time;Time_unit;Period;Data_type;Y_unit;Pts
0  0  201710311200  MINUTE  525600  -1  NOK  2
#            Time;      f(t)
201710301200   2000
201710301800   8000
```

```
JUNCTION     tunnel_2_min_flow  MyJunction
#Id;Number;Start_Time;Time_unit;Period;Data_type;Y_unit;Pts
0  0  201710311200  MINUTE  525600  -1  M3/S  2
#            Time;      f(t)
201710301200   0
201710301800   10
```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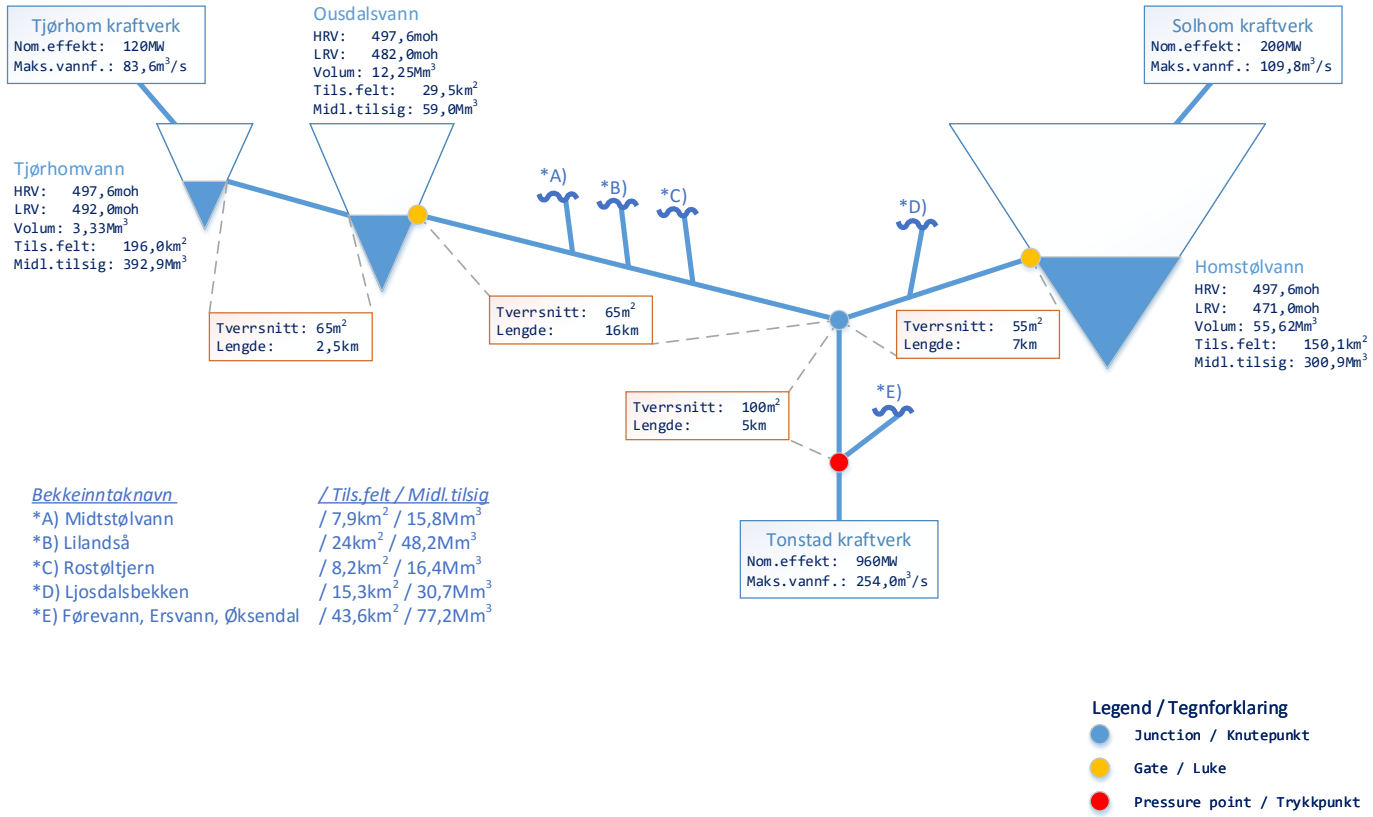
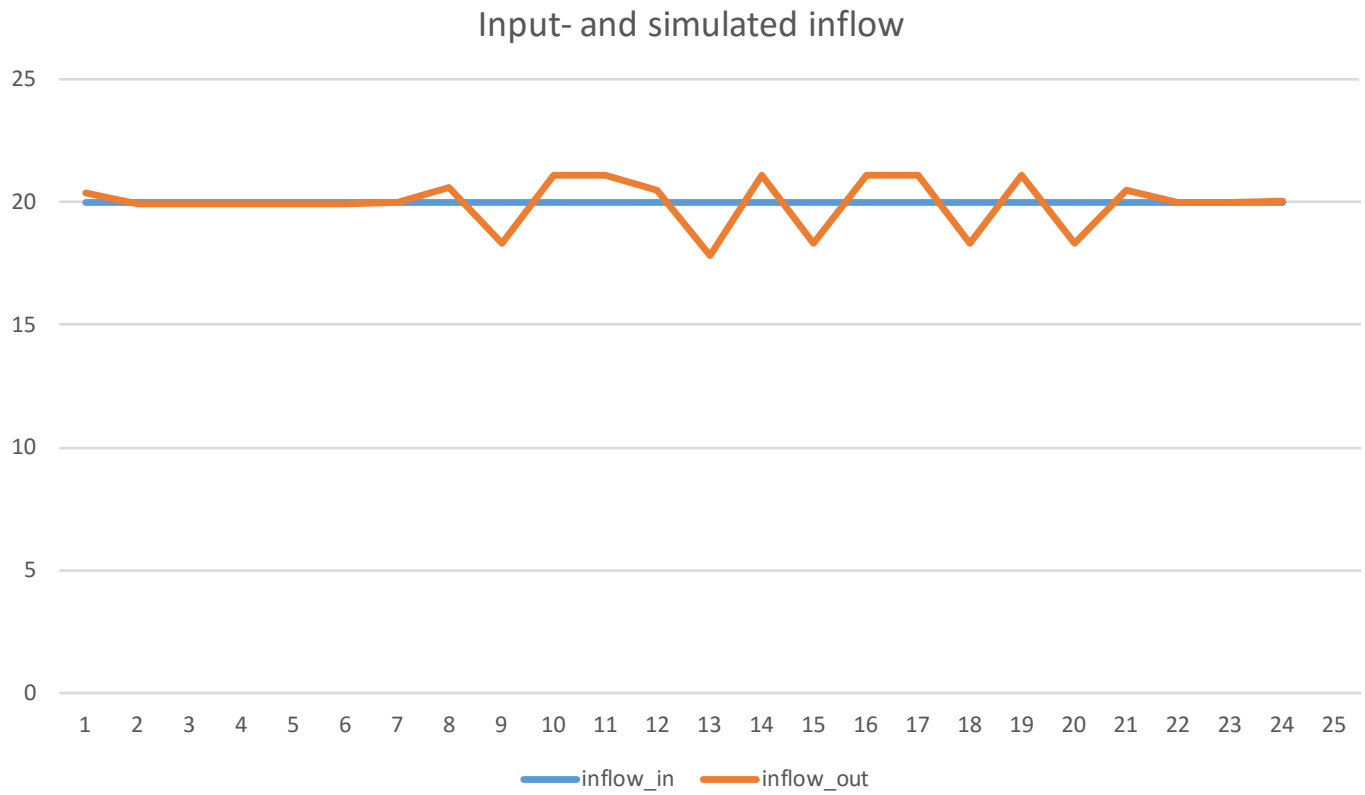
Case study – Sira Kvina

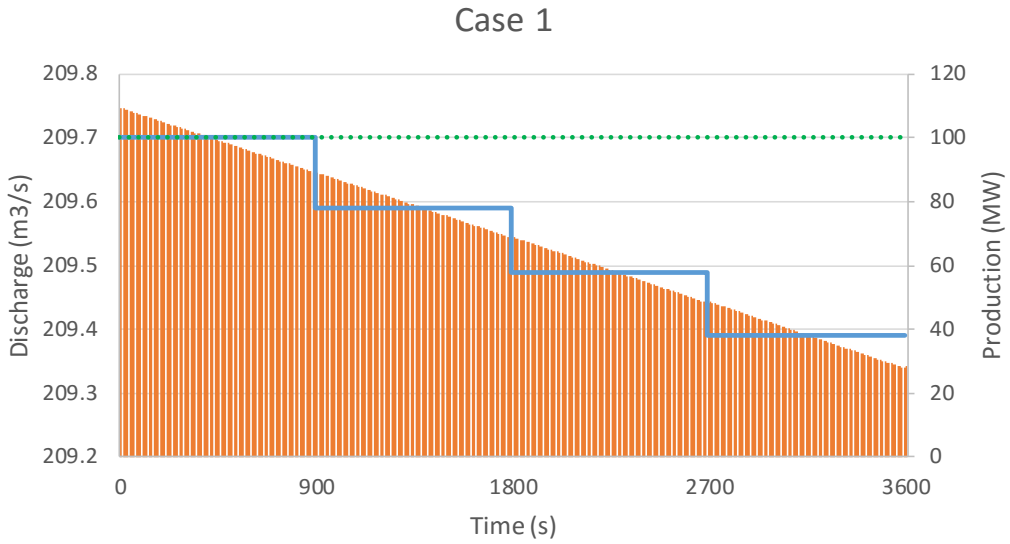
- Knutepunkt Ousdalsvann – Homstølvann er usymmetrisk både mht magasinvolum, kapasitet og tunnellengde.
- Høydeforskjell mellom Tjørhomvann og Homstøl på 3-6 meter ved normalt tilsig.
- For å trekke nok vann fra Ousdalsvann ved høyt tilsig må Homstølvann senkes for fortsatt kunne kjøre Tjørhom kraftverk uten overløp i Tjørhomvann.
- Ved stort eller overraskende tilsig er det ikke nok i senke Homstølvann. Da kan luken til Homstølvann lukkes helt eller delvis.

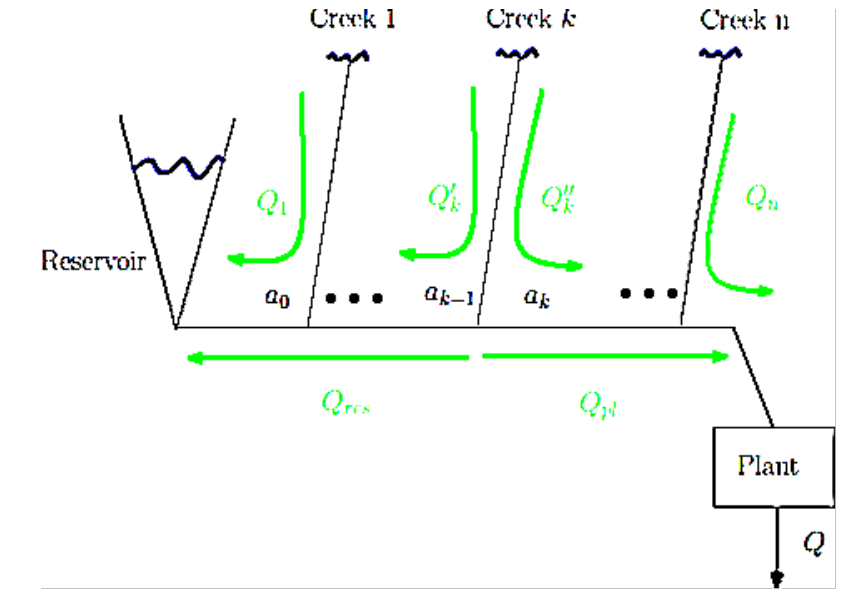
Case – Junction gate



Water budgeting with SHOP-SIM







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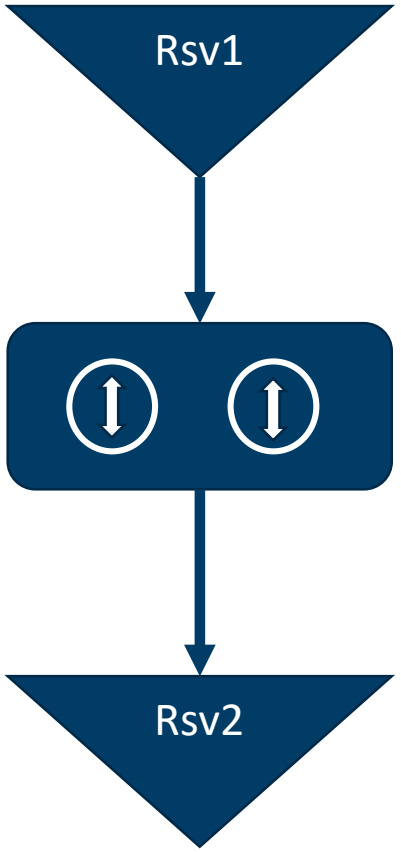
Head optimization

Gen: $p_{out} = \eta(h,q) \cdot g \cdot h(v,q) \cdot q$

Pump: $p_{in} = 1/\eta(h,q) \cdot g \cdot h(v,q) \cdot q$

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

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



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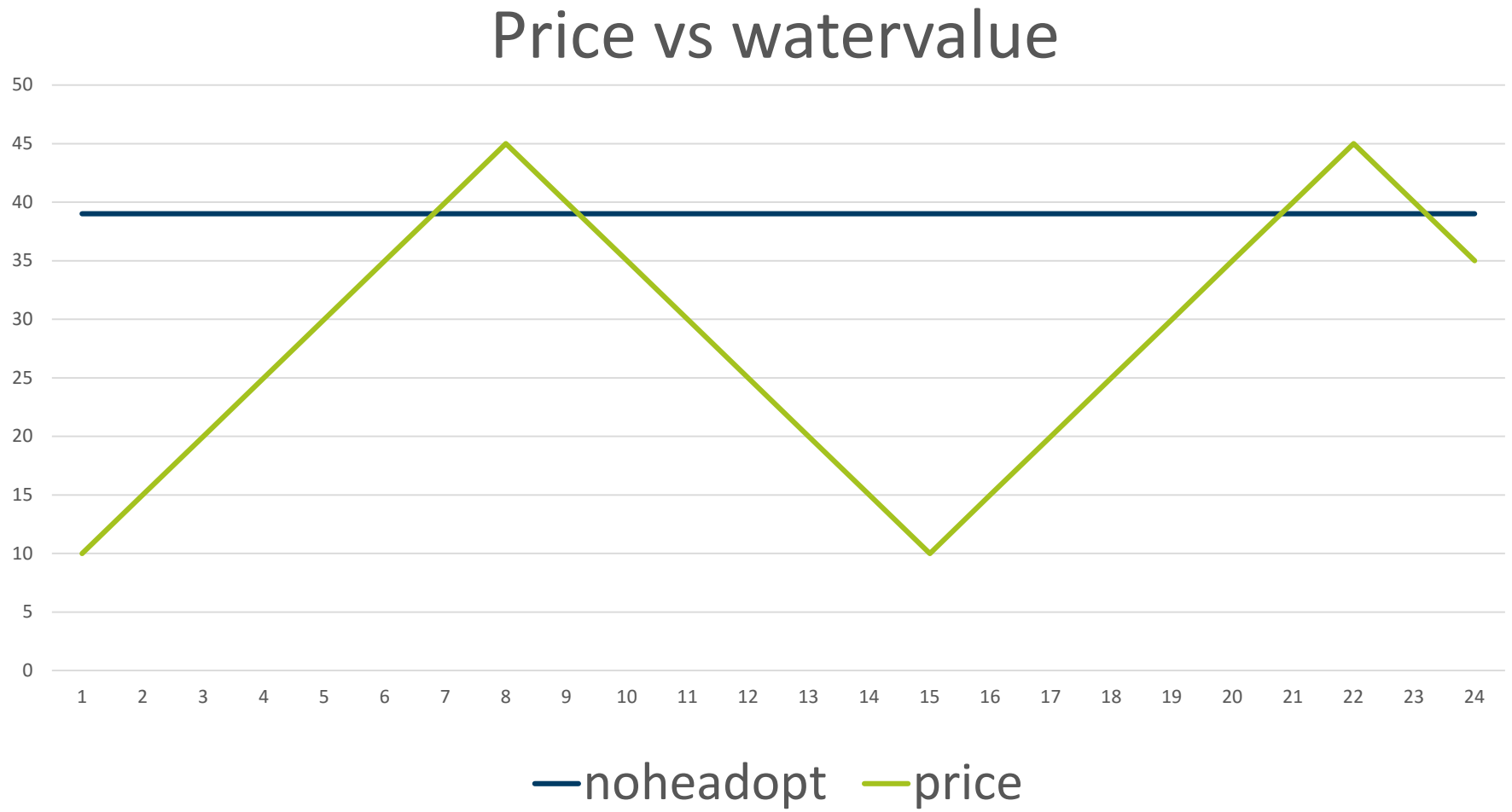
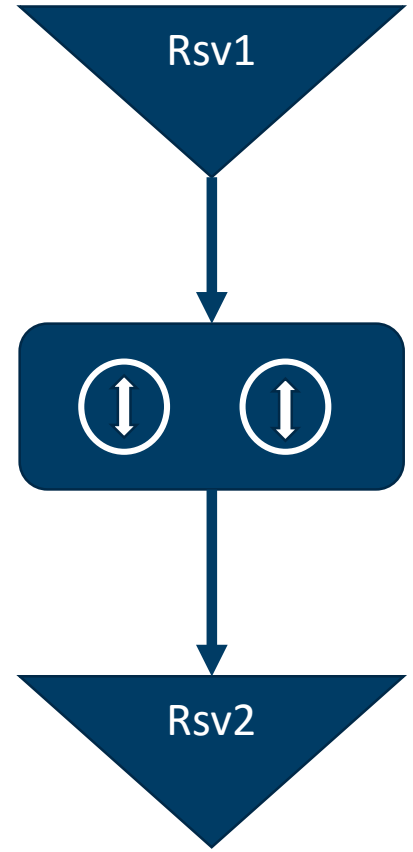
Head optimization for pumps





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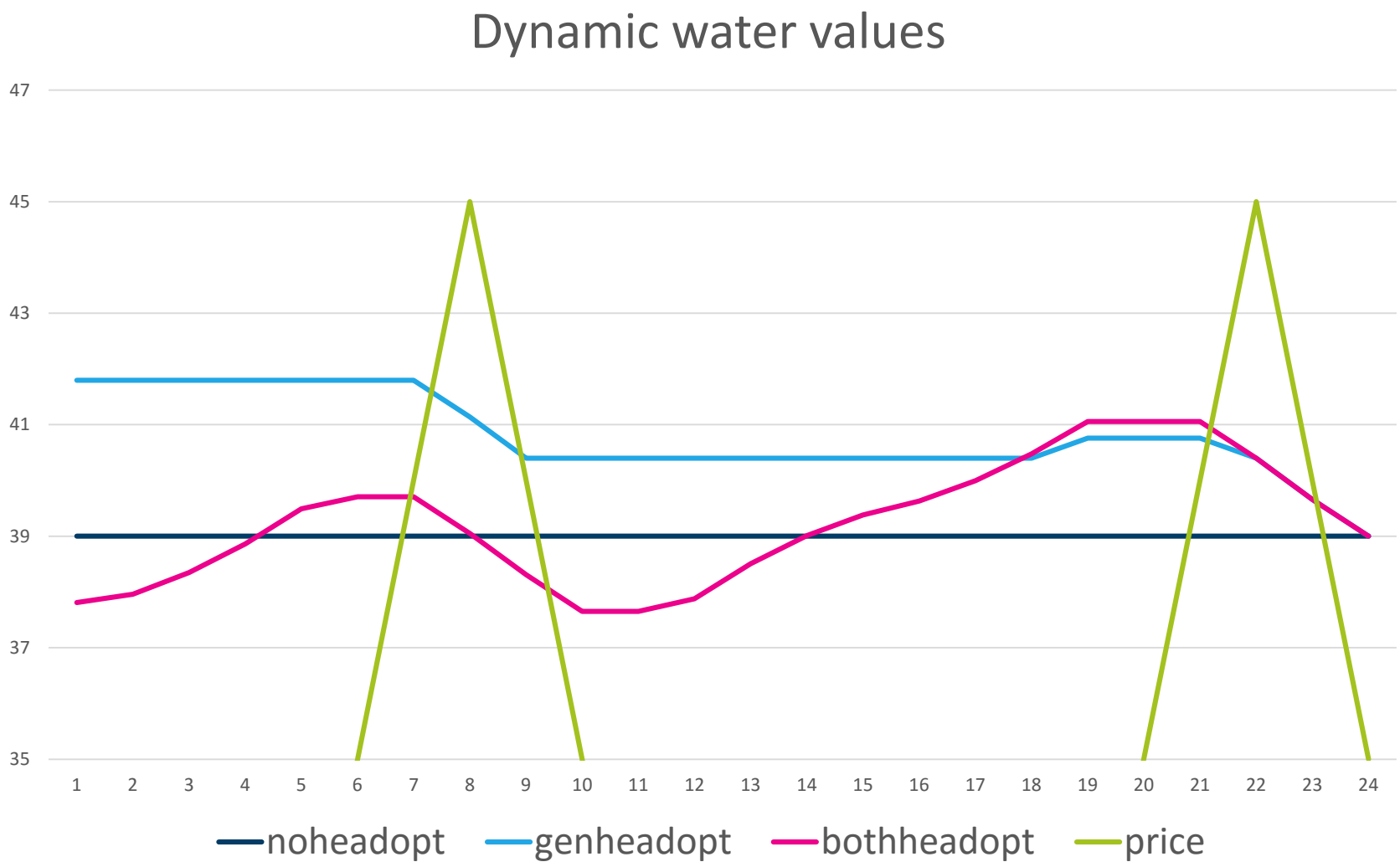
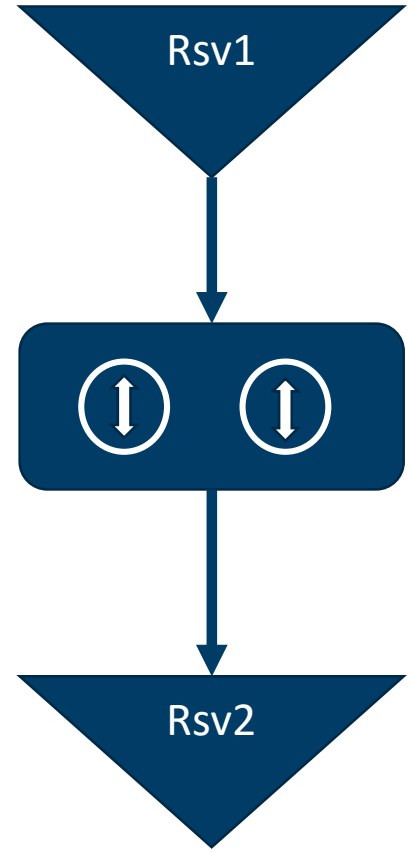
Head optimization for pumps





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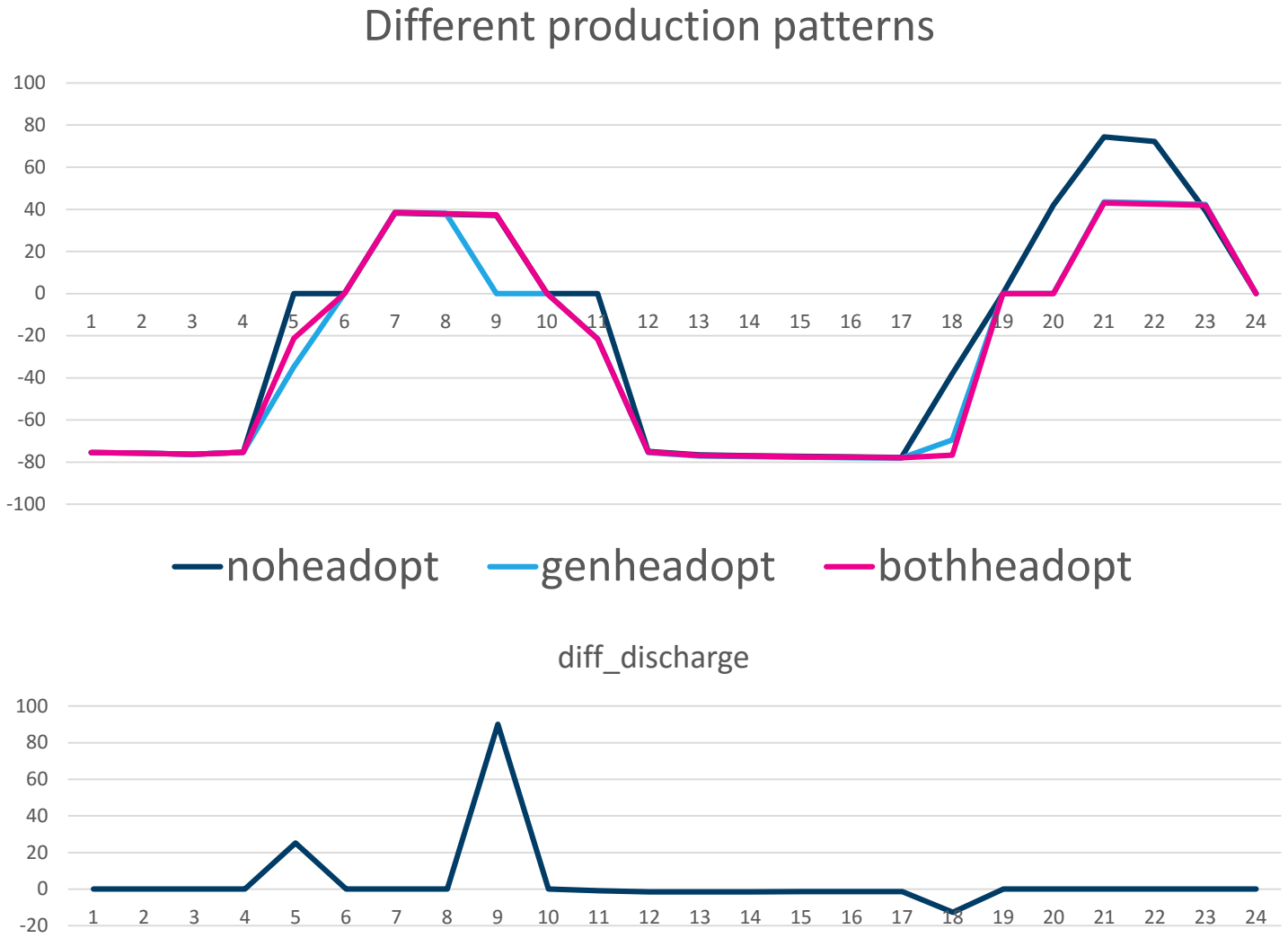
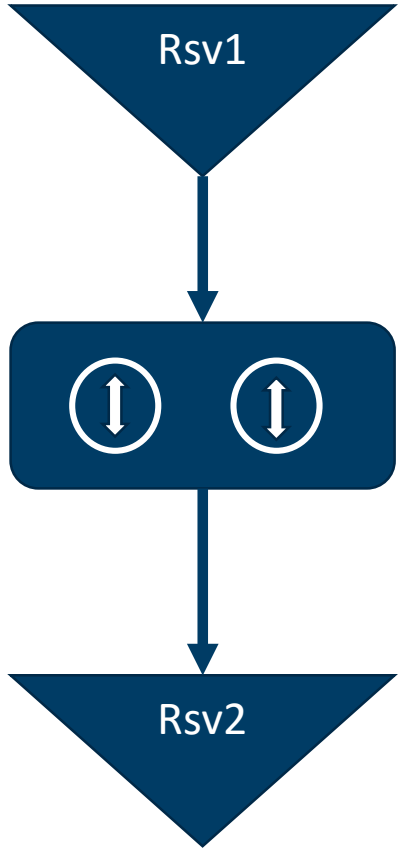
Head Optimization – Production comparison





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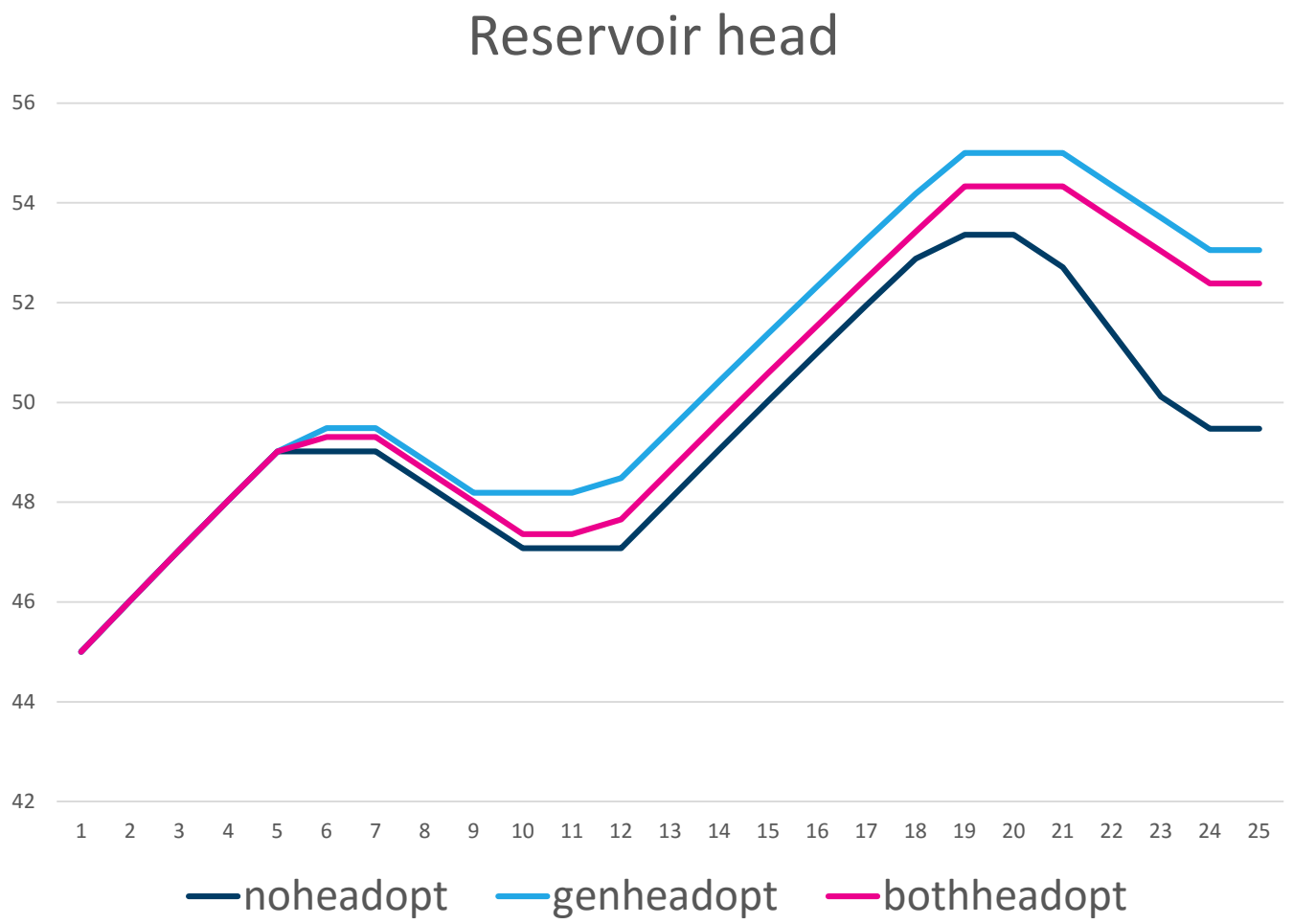
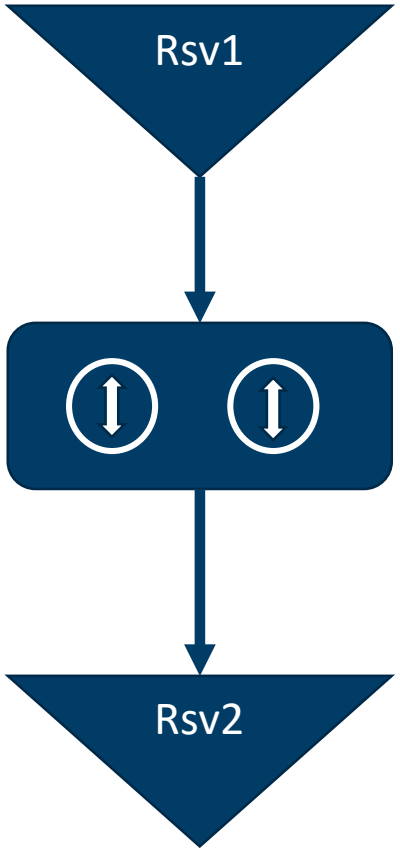
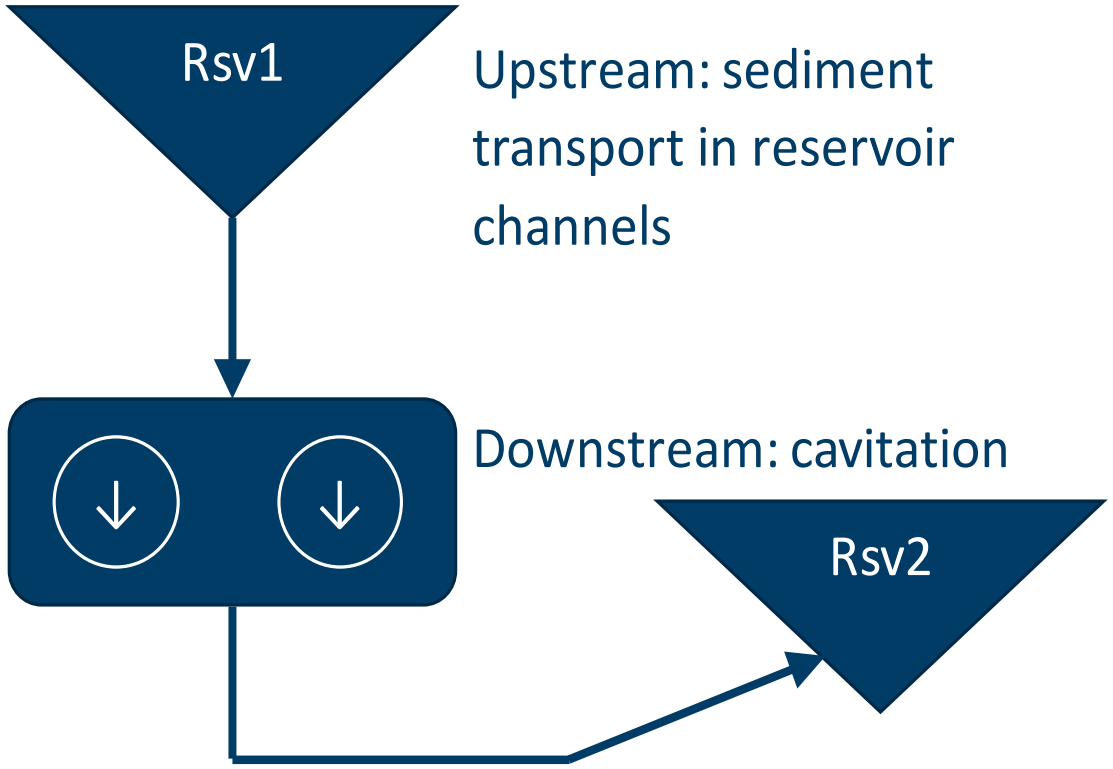
Head Optimization – Reservoir trajectory comparison

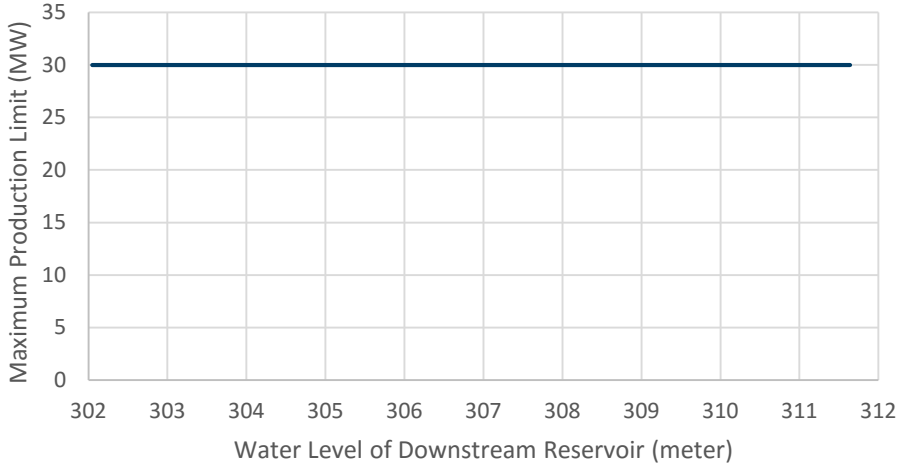




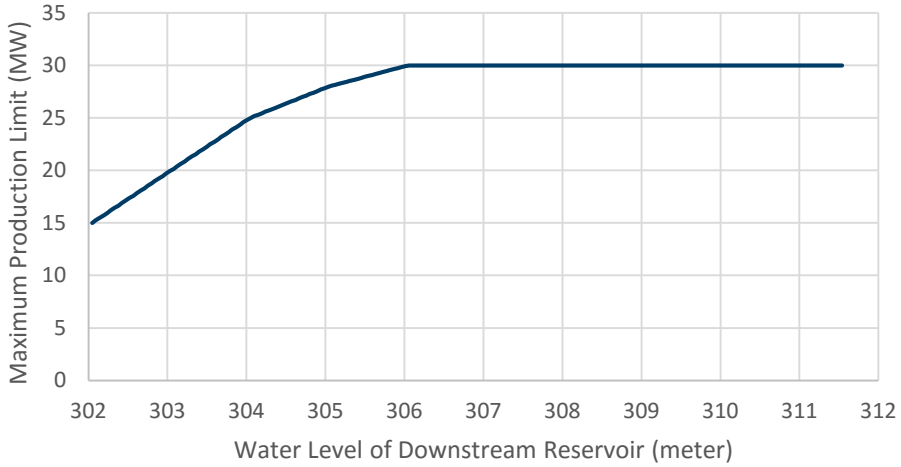
Plant discharge limits depending on water level of reservoirs



Without reservoir level production limits



With reservoir level production limits (linear)



GENERATOR **p_max_limit_rsv_down** Junsterforsen 1

#Id; Number; Reference; Pts; X_unit; Y_unit

42325 0 0 4 meter MW

#x_value; y_value;

303 20

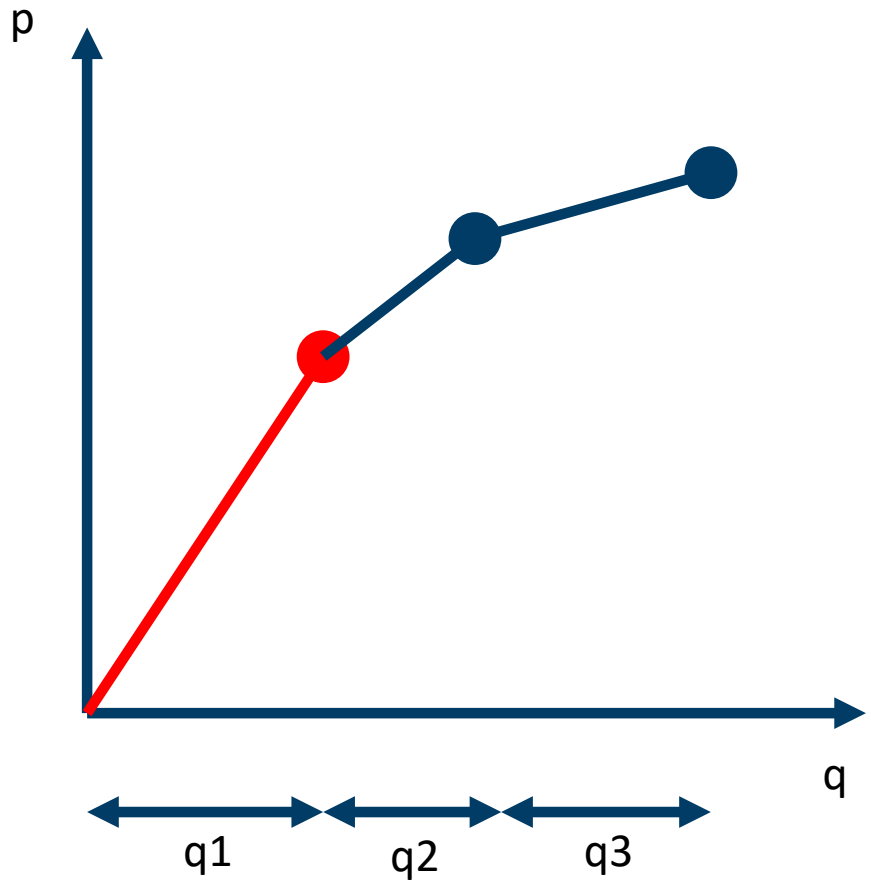
304 25

305 28

306 30

Discharge cost below best point in SHOP

- Normal situation: segment 1 (q1) has the best p/q-ratio, and will be used first by the optimization. This is correct, since it starts from 0 and is the first part of the p/q-curve.



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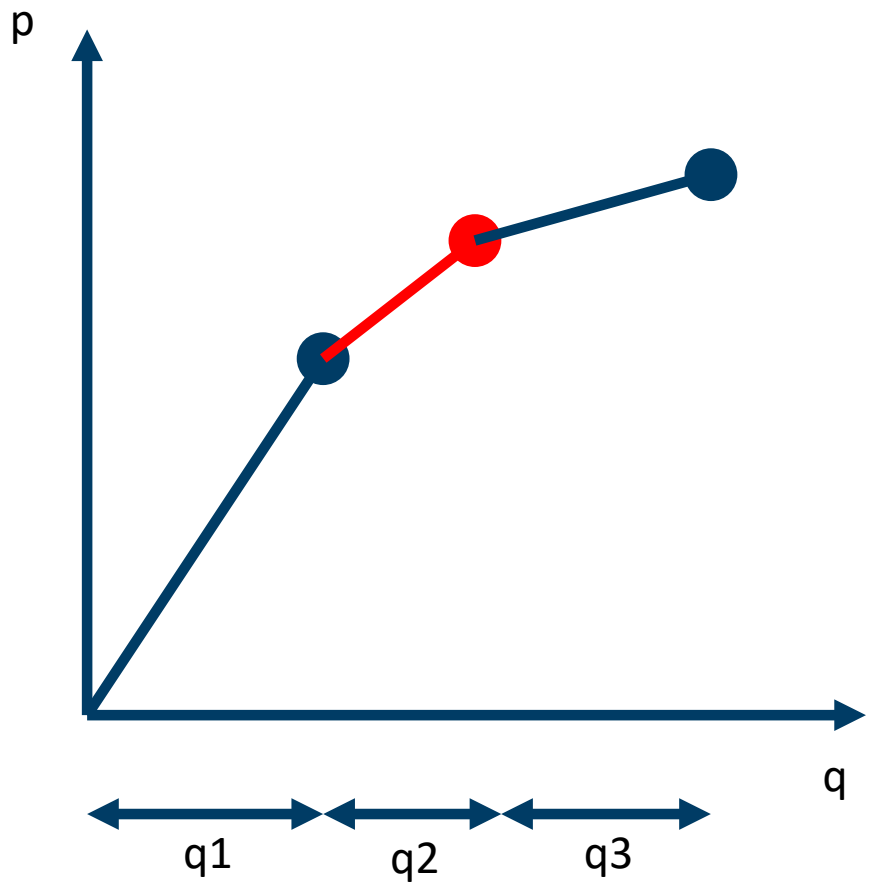
Discharge cost below best point in SHOP

- New situation: segment 1 (q1) has an additional discharge cost due to cavitation, and the optimization chooses to use segment 2 (q2) before segment 1. This is not correct, since it is not the first part of the p/q-curve.



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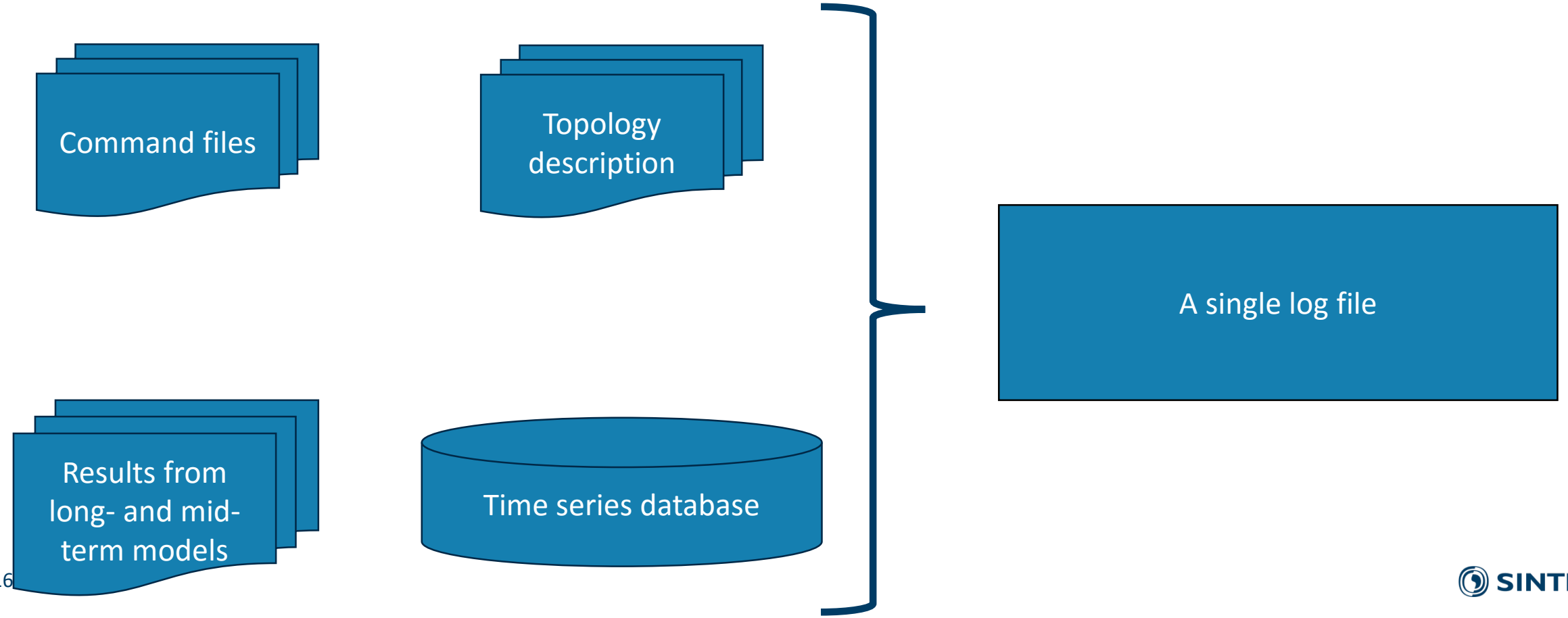
Discharge cost below best point in SHOP

- Tested possible solution: model segments 1, 2 and 3 as different production zones on the same generator. Binary variables are added automatically by SHOP to make sure the zones follow the correct order.
- Problem found when testing this: The discharge cost curve uses its own set of segments, independent of the production zones. Although the zones are used correctly, the discharge cost segments are not.

Discharge cost below best point in SHOP

- The conclusion: Need to add binary variables to the discharge cost curve as well. This has not been done in SHOP before, and some more work is required before it can be finished.

Case reporting format



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Example of code generating log file

```
bool SetIntValue(char* objectType, char* objectName, char* attributeName, int value)
 {
   lock(ThisLock)
   {
     std::string isoObjectName = UTF8toISO8859_1(objectName);
     if (pyLog)
       fprintf(pyFile, "shop.SetIntValue(\"%s\", \"%s\", \"%s\", %d)\n", objectType,
isoObjectName.c_str(), attributeName, value);
```

Original file

```
import pandas as pd
import matplotlib.pyplot as plt

from pyshop import ShopSession

#Create a new SHOP session.
shop = ShopSession('', '', False, 'case.log')

#Set time resolution
starttime=pd.Timestamp('2018-02-27')
endtime=pd.Timestamp('2018-02-28')
shop.set_time_resolution(starttime=starttime, endtime=endtime, timeunit='hour')

#Add topology
rsv1=shop.model.reservoir.add_object('Reservoir1')
rsv1.max_vol.set(12)
rsv1.lrl.set(90)
rsv1.hrl.set(100)
rsv1.vol_head.set(pd.Series([90, 100, 101], index=[0, 12, 14], name=0))
rsv1.flow_descr.set(pd.Series([0, 1000], index=[100, 101], name=0))

plant1=shop.model.plant.add_object('Plant1')
plant1.outlet_line.set(40)
plant1.main_loss.set([0.0002])
plant1.penstock_loss.set([0.0001])

p1g1=shop.model.generator.add_object('Plant1_G1')
plant1.connect().generator.Plant1_G1.add()
```

Resulting log file

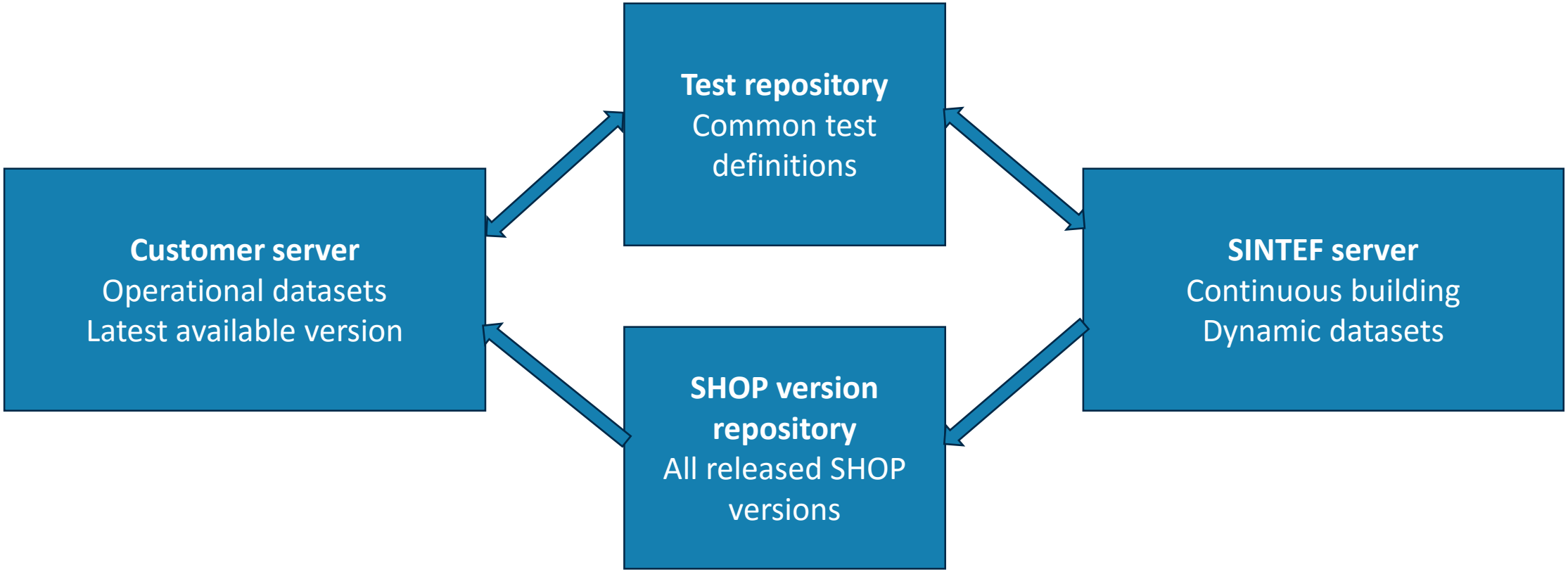
```
#  -*- coding: iso-8859-1 -*-
import pyshop
import numpy as np
import os

def init_shop_api(dll_path, license_path):
    import shop_pybind as pb
    return pb.ShopCore(False)


shop = init_shop_api("", "")

shop.GetObjectNamesInSystem()
shop.GetObjectTypesInSystem()
shop.GetCommandTypesInSystem()
shop.SetTimeResolution("20180227000000", "20180228000000", "hour")
shop.AddObject("reservoir", "Reservoir1")
shop.GetObjectNamesInSystem()
shop.GetObjectTypeAttributeNames("reservoir")
shop.GetObjectTypeAttributeDatatypes("reservoir")
shop.SetDoubleValue("reservoir", "Reservoir1", "max_vol", 12)
shop.SetDoubleValue("reservoir", "Reservoir1", "lrl", 90)
shop.SetDoubleValue("reservoir", "Reservoir1", "hrl", 100)
shop.SetXyCurve("reservoir", "Reservoir1", "vol_head", 0.000000, [0,12,14], [90,100,101])
shop.SetXyCurve("reservoir", "Reservoir1", "flow_descr", 0.000000, [100,101], [0,1000])
shop.AddObject("plant", "Plant1")
shop.GetObjectNamesInSystem()
shop.GetObjectTypeAttributeNames("plant")
shop.GetObjectTypeAttributeDatatypes("plant")
shop.SetDoubleValue("plant", "Plant1", "outlet_line", 40)
shop.SetDoubleArray("plant", "Plant1", "main_loss", [0.00020000000000000001])
shop.SetDoubleArray("plant", "Plant1", "penstock_loss", [0.0001])
shop.AddObject("generator", "Plant1_G1")
```

~~Test~~ User driven development



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Teknologi for et bedre samfunn