Benchmarking optimization in the hydropower plant Driva

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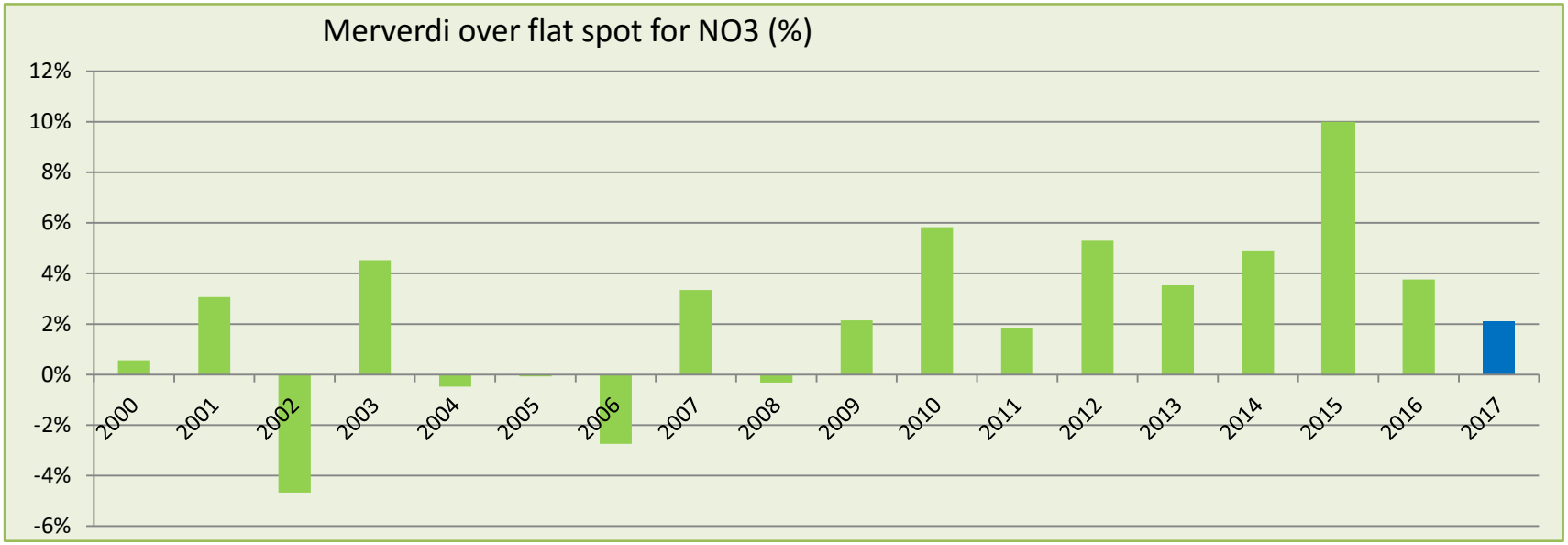
Current benchmark of physical production within TEK



- Cover the complete value chain from long-term optimization to dispatching production units in TEK including wind-power
- Current benchmark shows that things are getting better
- It’s not providing any information about other aspects within the value chain

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Why undertake such a project?

- Increased focus on benchmarking
- Create a better benchmark for future use
- Make us able to prioritize among projects
- Increase the awareness and confidence of the optimization process within TEK(TrønderEnergi Kraft)

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Project scope given to SINTEF

- Primary objective
  - Evaluate TEK performance
- Secondary objectives
  - Quantify monetary value of granularity of price-section in price-forecasts
  - Quantify monetary value of different price-forecasts
  - Quantify monetary value of using constant water-values or cut-values
  - Quantify monetary value of snow pack forecast

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Brief description of the simulator made by SINTEF

- Long-term model
  - Model provided by TEK and is kept unchanged during the whole simulation period
  - Runs VanSimTap/Seasonal-model once every week in python with use of an API
  - Starting point is given by SHOP-model(except for the first run)
  - Input is forecasts available at any given run-date
  - Output is water-values
- Short-term model
  - Model provided by TEK and is kept unchanged during the whole simulation period
  - Water-values provided from seasonal model
  - Run once, or sometimes twice a day due to some state-dependent restrictions in python with use of an API
  - Prices are known up to 14 days in advance
  - Inflow is known up to 14 days in advance
  - All historical restrictions/ availabilities are used
  - Starting point given by previous SHOP-run
  - Output is all the values that SHOP returns
  - Nominated production is set equal to SHOP-plan for the next day

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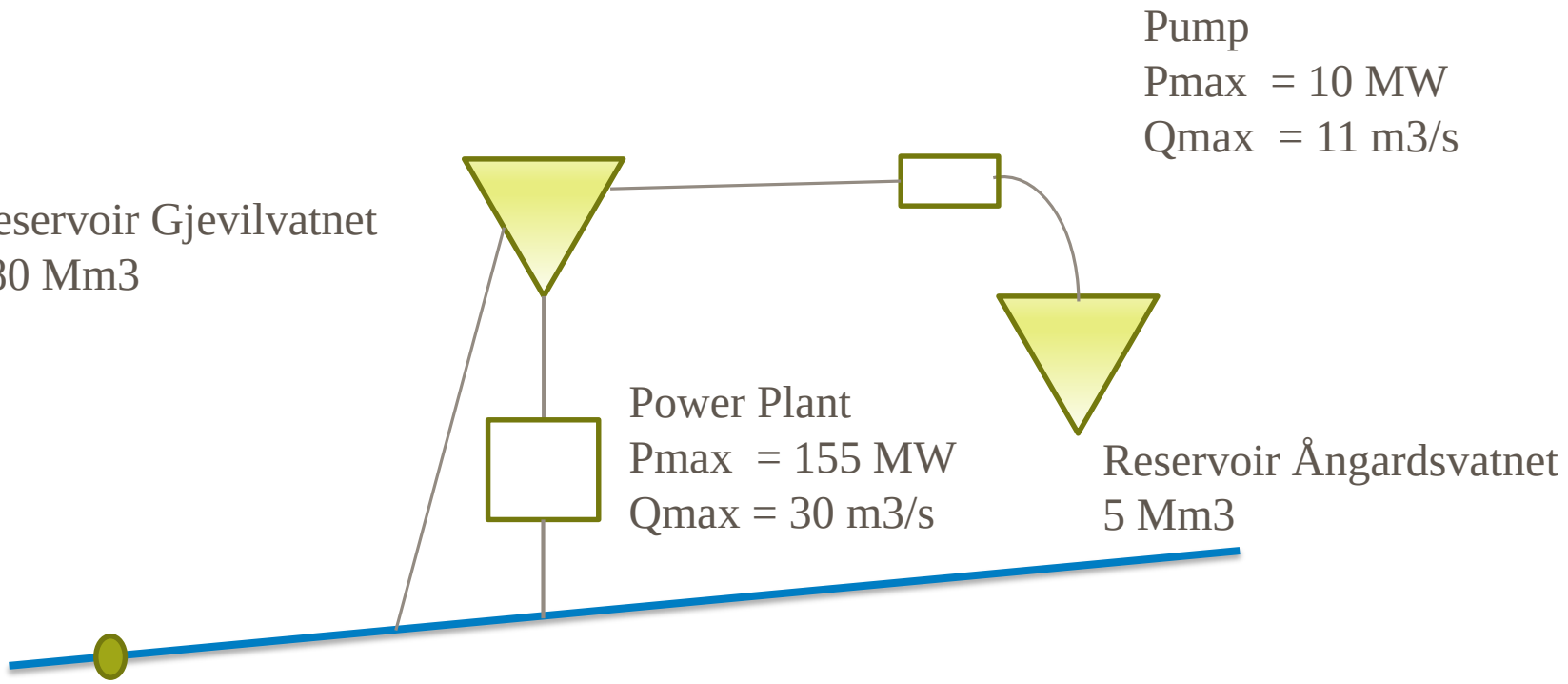
Schematic description of the Driva-system

Annual production
625 GWh



Minimum release constraint
10 m3/s

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Running and verification of model results

- Simulation from 03.01.2005 until 03.01.2016 by SINTEF
- TEK has verified, with the use of hourly simulation results, that all variables are within bounds of the restrictions. This applies for both absolute restrictions and state-dependent restrictions
- Hence, results from a simulation will mimic a feasible nomination/production from the power plant Driva within the bounds and regulation it's subject to

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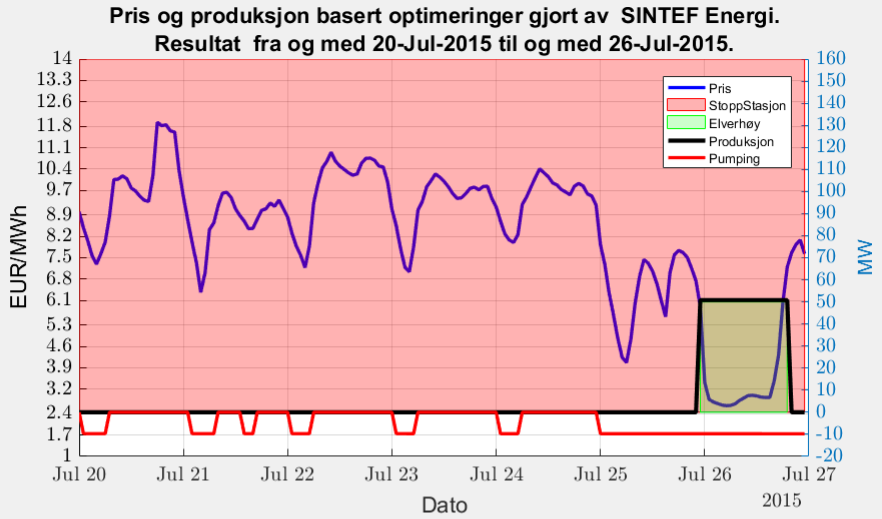
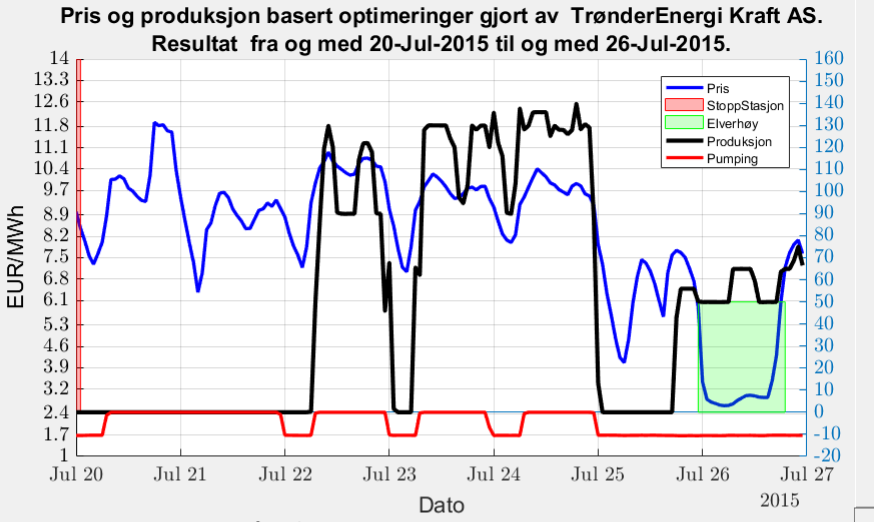
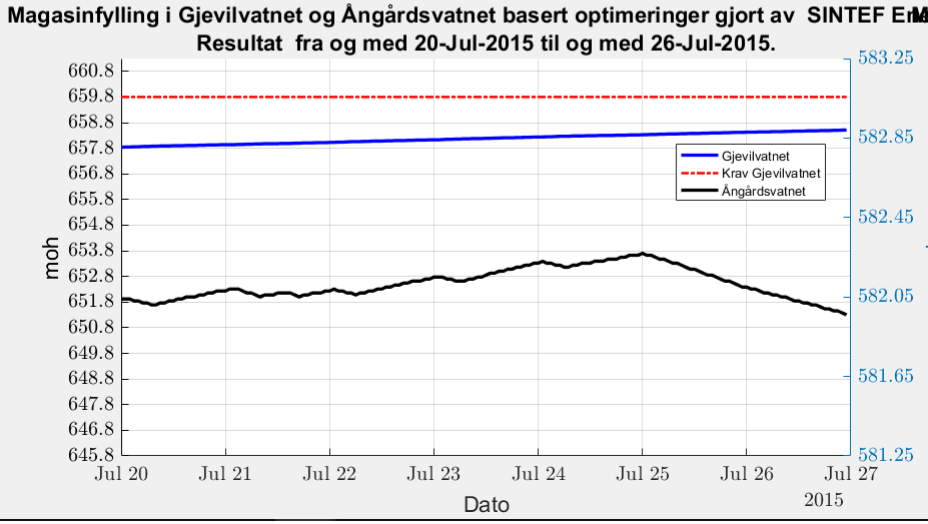
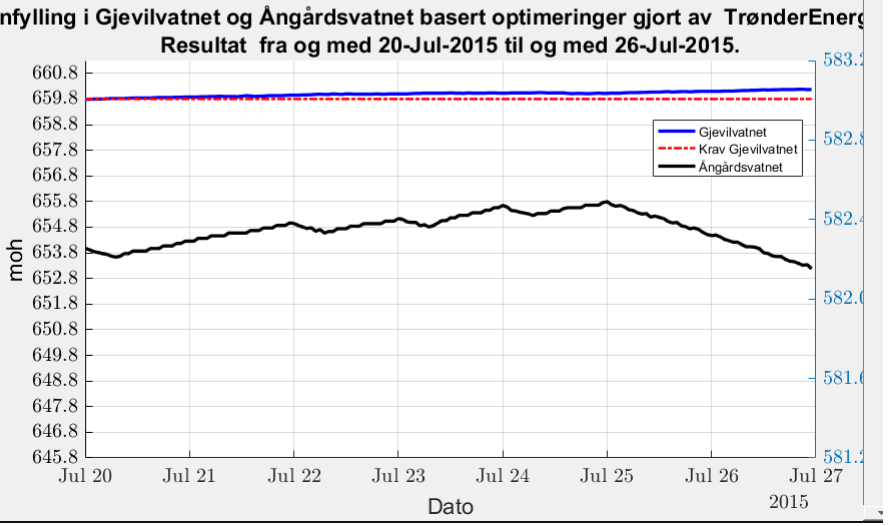
Example of verification









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What have been analysed

Case Nr	Case Name	Price Forecast	Spring Flood forecast	SHOP water value	Number of Price Levels
1	Base case	Marked Adjusted	TEK	Cut	4
2	SKM price	SKM original	TEK	Cut	4
3	Det Price	Deterministic	TEK	Cut	4
4	No Snow Forecast	Marked Adjusted	None	Cut	4
5	Constant WV	Marked Adjusted	TEK	Constant	4
6	Price Adjusted WV	Marked Adjusted	TEK	Price Adjusted	4
7	Perfect Snow forecast	Marked Adjusted	Perfect	Cut	4
8	Det Price Perfect snow forecast	Deterministic	Perfect	Cut	4
9	Det Price no snow forecast	Deterministic	None	Cut	4
10	11 Price Levels	Deterministic	TEK	Cut	11

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Weakness in the analysis, not in method

- Long-term
  - Short analysis period
  - Model is kept constant which affect the comparison with the historical data(lacking historical model data)
  - Forecast of snow pack is not consistent over the whole period
  - For part of the analysis period is the implementation of price-section done in quite a different manner than in the operational long-term planning
- Short-term
  - The model has perfect information about price and inflow(lacking historical data)
  - Model is kept constant, which affect the comparison against historical data(lacking historical model data)
  - SHOP period differ from operational use during the whole analysis period(lacking historical data)
  - Some restrictions could not be used in SHOP or had to be used in a simplified way

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Results

- For obvious reasons only a small portion of all results will be presented here
- In general terms the project has delivered results according to our expectations
- Some of the cases have yielded surprising results
- Further analysis will be and have been conducted based on results from this project

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Some results

Table 5.2 Yearly and total income (in Mil EURO) in the period 2005-2015 as observed and as simulated in the 10 cases. The table reports also the value of the Gjevilvannet reservoir at the end of the year in (Mil EURO) and in [GWh].

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Tot
Observed	19.9 (11.2) [335.8]	24.6 (10.2) [342]	21.3 (14.3) [337.8]	34.9 (10.5) [251.4]	18.8 (11.2) [268]	34.8 (21.4) [251.8]	29.3 (10.9) [325.9]	24.8 (8) [242.4]	19.5 (8.2) [286.3]	14.4 (6.4) [221.4]	11.2 (3.5) [229.9]	253.5
Base case	18.5 (12.3) [369]	29.6 (8.1) [274.6]	18.1 (15.5) [365.8]	36.9 (9.1) [218]	17.5 (12) [285.3]	41.6 (15.5) [181.9]	25.2 (11.4) [339.4]	24.3 (9) [270.6]	22.7 (7) [244.3]	14.5 (4.3) [149.5]	10.3 (3) [198.5]	259.2
Det Price	18.5 (12.8) [383.5]	35.8 (4.2) [146.7]	16 (14.5) [341.1]	40 (7.1) [169]	13.2 (14.7) [350.4]	41.8 (20.9) [245.1]	30.5 (10.4) [310.8]	23.9 (9.1) [276]	25.9 (4.4) [155.7]	13.5 (2.9) [101.1]	8.5 (3.4) [224.4]	267.6

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Comments on the results

- Performance in the start of the period is showing large deviation from optimal(SINTEF base case)
- Some of the issues creating these large deviations has been addressed
- In the latter part of analyse period, historical revenue and SINTEF base case revenue tend to converge
- However, still possible to increase revenue

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Conclusion

- Still things to be done and therefore hopefully no risk of join the ranks of the unemployed

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