

EXPERIENCES WITH SHOP-BASED SIMULATOR

Tellef Juell Larsen

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Background

- ▶ Need for harmonisation of the planning process in Norway and Sweden
 - The central dispatch and the 4 Norwegian control centres applies SHOP for planning, while the Swedish control centre mainly applies SmG SIM.
 - Need for a common tool with both optimization and simulation



- ▶ 3 alternatives
 - Adapt the existing SmG-simulator
 - Develop a simulator in SHOP
 - Develop a simple in-house simulator



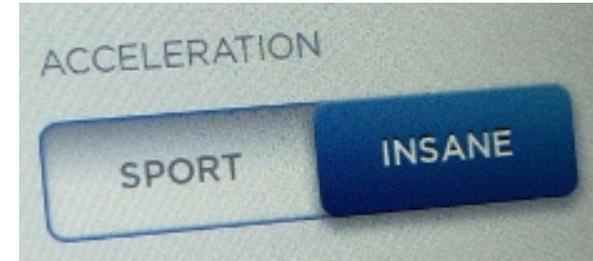
Sourcing project: SmG- or SHOP-simulator?

- ▶ Thorough investigation of drawbacks and advantages
- ▶ Development of SHOP-simulator was chosen finally
- ▶ Some advantages with a SHOP-simulator:
 - Maximum consistency with optimization, and within the short-term scheduling
 - One API – no additional effort to integrate into internal tools using SHOP
 - A new file-less WCF-API will reduce the API-time for optimization as well
 - Probably faster API and simulation
 - Some topologies/functions in SHOP not available in SmG
 - Coordinated and synchronous improvements and error handling with optimization
 - Future cross-over possibilities, e.g. combination of simulation and optimisation
 - One vendor



Requirements to the simulator

- ▶ Fast
 - Less than 1 sec. for a one week simulation of a price area
- ▶ Same API for optimization and simulation
 - Existing file based ascii-API
 - New WCF-API, for direct file-less communication between GUI and SHOP
- ▶ «Dumb»
 - Pure simulation, without optimization or heuristic/rule-based algorithms
 - All generator and gate schedules must be given as input
 - Reservoir development and discharge of deltameters, junctions and overflows are calculated
 - Infeasibilities are warned, but not avoided.
E.g. empty reservoir, full reservoir without spill, plan above maximum turbine efficiency



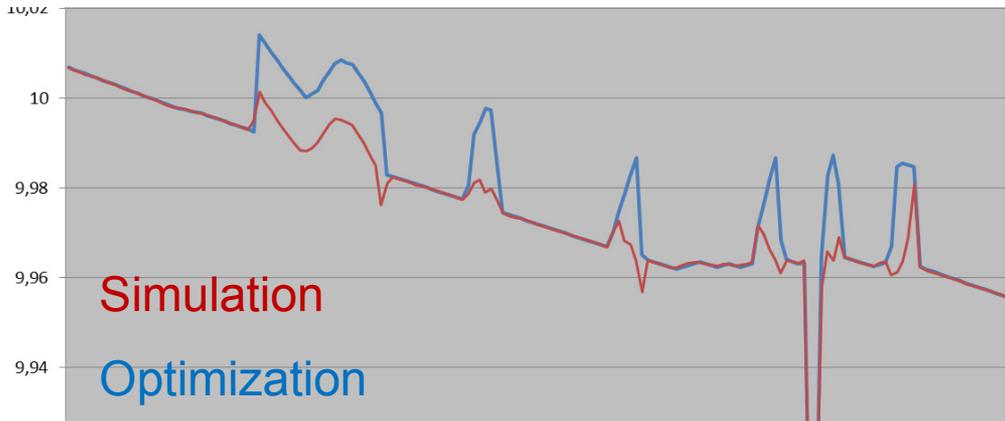
Verification of simulator

- ▶ Strategy: Compare simulation with optimization
 - All differences should be due to errors or weaknesses in optimization
- ▶ Procedure
 - Optimize a price area
 - Use generator and gate schedules from optimisation as inputs to the simulation
 - Simulate with the same time resolution
 - Compare reservoir and discharges graphically to reveal differences
 - Decide whether any differences are due to errors in the simulator

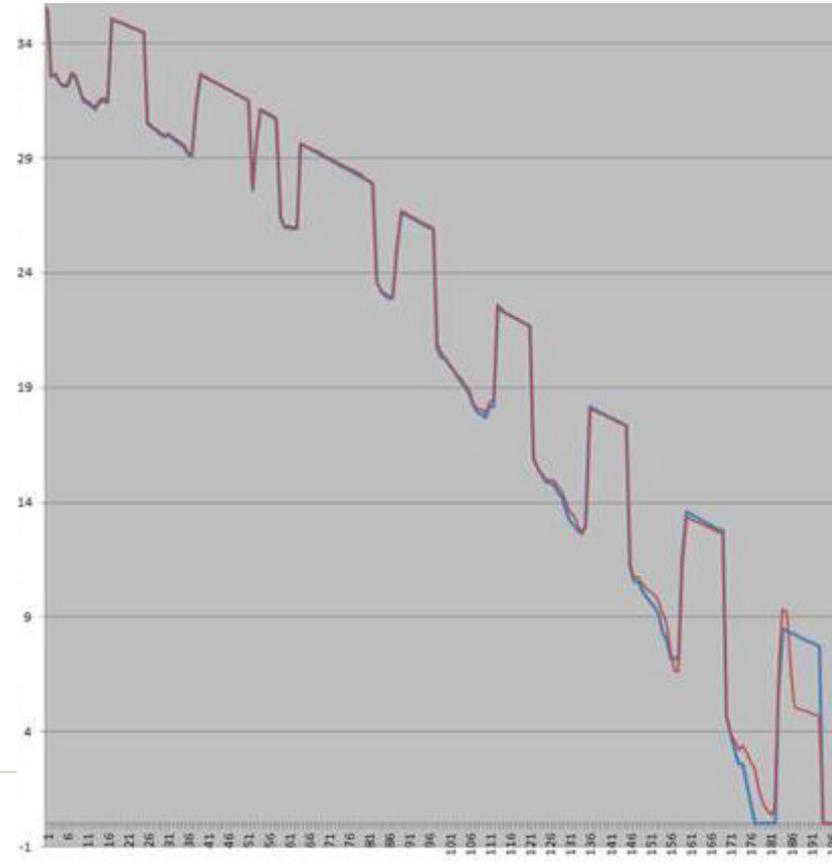


Examples of deviations from optimization

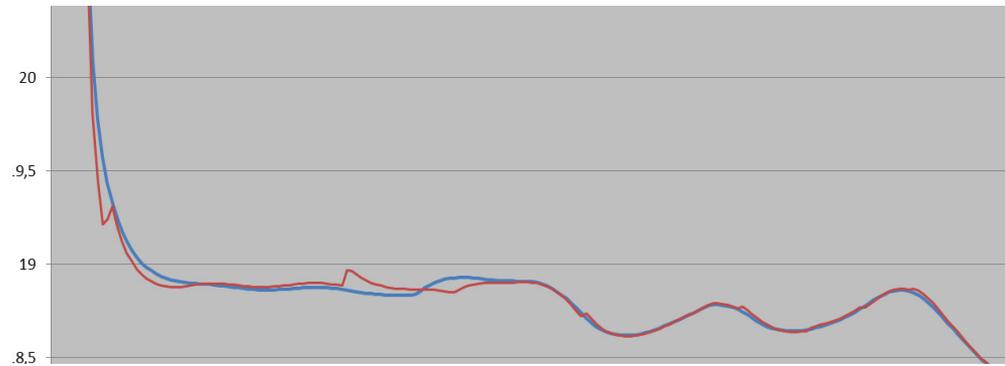
Reservoir level



Junction flow – error



Plant discharge



Test of calculation times

- ▶ Core simulation time, exclusive API-time
- ▶ 210 time steps

Results

- ▶ Leirdøla; 1 plant, 1 reservoir: 14 ms
- ▶ Tokke: 7 plants, 11 reservoirs: 124 ms
- ▶ NO4: 16 plants og 21 reservoirs : 265 ms
- ▶ SE2: 17 plants og 25 reservoirs : 296 ms
- ▶ Sweden: 52 plants og 74 reservoirs, 874 ms
- ▶ Norway: 71 plants, 107 reservoirs : 1466 ms



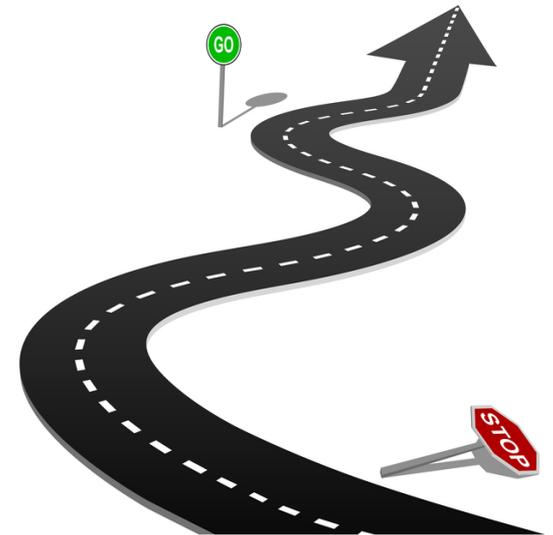
Experiences

- ▶ The SHOP-based simulator is working as requested
 - Consistent with the optimisation
 - Fast
- ▶ The optimization is quite good, but some weaknesses are revealed/confirmed
 - Generator efficiency is referred to generator, not turbine
 - Head optimization should be based on the average reservoir level of the time step of the previous iteration, not the start reservoir level
 - Deltameter modelling
 - Accuracies
- ▶ New competence and new ideas
 - For SINTEF as well



Status and plans

- ▶ First release delivered one week ago
- ▶ Now available for operative testing in our user interface
 - for simulation of manual corrections of optimized plan
 - new user areas to be implemented ASAP
- ▶ Ideas for further improvement
 - Calculation of economic results
 - consistent with the objective function from optimization
 - Simulate behaviour of regulator controlled gates and plants



THANK YOU

Tellef Juell Larsen, PhD

R&D-responsible short-term energy management
MNP, Market Nordic Production optimisation

-- DIRECT +47 24 06 70 78
-- MOBILE +47 90 96 45 96

Statkraft AS

Lilleakerveien 6, Postboks 200 Lilleaker, 0216 Oslo



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www.statkraft.com