Complex Cascade Dams Operation – The Glommen and Laagen Case

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About GLB

Glommens og Laagens Brukseierforening (GLB)
is a Water Management Association for the largest river system in Norway.
• Catchment area: 42 000 km²
  – 13 % of Norway (0-2469 masl)
• 21 reservoirs and 5 diversions
  – Storage capacity: 3 500 mill.m³
• 50 hydroelectric powerstations
• Inst. capacity: 2 500 MW
• Production: 12 TWh/year
  – Appr. 9 % of Norway
“Regulate the water flow in the rivers Glomma and Laagen, within licensed conditions, in order to maximize energy production (economic outcome) in the hydropower stations. Commercial, but take into account all stakeholders”
Effect of regulations and diversions is about 2,5 TWh/yr (~20 % of total production).

Additional economic effect caused by variations in electricity price.
Requirements for operating the river system

Sufficient and reliable observations

Weather forecasts

Well calibrated hydrological models

A river system model to link the sub catchments together and for planning how to operate

A model for optimizing the total profit within actual weather forecasts and known restrictions in the river system
Sufficient and reliable observations

GLB operates ~125 hyd./met. stations with hourly time resolution
Weather forecasts (precip.+temp.) 10 days ahead for specified areas are imported every morning into the hydrological models.
Well calibrated hydrological models

For each sub catchment a hydrological model is calibrated on historical data to establish the connection between the model input (precipitation and temperature) and output (runoff).

With this model runoff can be forecasted based on the meteorological forecast.
GLB simulates runoff daily for 40 sub-catchments using the HBV model.
Schematic representation of the river system model

- Reservoir (water level, inflow, outflow)
- Discharge station (river flow)
- River
- Diversion
- Power plant

River system model
River system model - examples

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Reservoir Lake Aursunden
Discharge station – power plant Røstefossen
River system model – Reservoir; Lake Aursunden

- Inflow (unregulated)
- Outflow (regulated)
- Production capacity

Water level

Limits
River system model – Discharge station; Røstefossen

- Local inflow (unregulated Aursunden – Røstefossen)
- Outflow Aursunden (regulated)
- Flow Røstefossen
- Production capacity Røstefossen

Graph showing m3/s from January 2016 to December 2016 with peaks in May and June.
River system model – Restrictions

Variable limits for water level in reservoirs – especially due to leisure activities in summer

Variable capacity in power plants due to upgrading and maintenance

Small variations in outflow/production in winter due to ice conditions in the river
Based on known restrictions, weather forecast for 10 days, and observed weather for the last 30 years, forecasts and plans are prepared daily.
River system model — forecast for river Glomma downstream all reservoirs

Published: 30.08.2017 Starting from: 29.08.2017 Sarpsfoss. plan: Flow, Runoff, total Reservoir -> Powerplant capacity: Fossumf./K., Vamma, Sarpsfoss.
River system model – forecast for river Glomma (totals)
Lake Øyeren 1967, a flooding situation hopefully to be avoided in the future due to activities to reduce floods and optimal use of upstream reservoirs.