



HYDRO

# Kuttkobling ProdRisk-SHOP «From cut-to-bids»

Physical market optimization

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# Outline of presentation

- About Hydro
- Background and Motivation
- Solution
- Results

# A resource-rich, global aluminium company

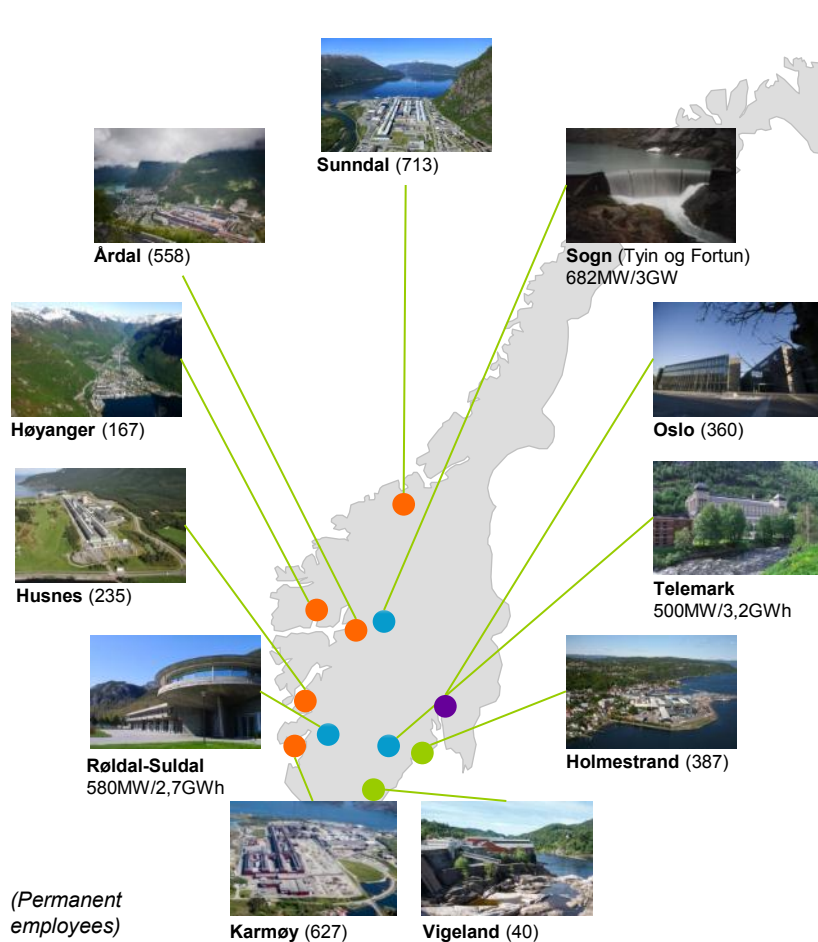
With robust positions across the value chain



- Global provider of alumina, aluminium and aluminium products
- Leading businesses along the value chain; raw materials, energy, primary metal production, aluminium products and recycling
- 13,000 employees involved in activities in more than 50 countries
- Market capitalization ~NOK 75 billion
- Annual revenues ~NOK 65 billion
- Included in Dow Jones Sustainability Indices and FTSE4Good

# Hydro in Norway

Knowledge-based mainland industry with significant spin-off effects



## • Operations

- 5 primary aluminium plants in Sunddal, Karmøy, Årdal, Høyanger and Husnes
- Rolling mill and recycling plant in Holmestrand
- 20 hydropower plants in Telemark, Sogn, Røldal-Suldal and Agder
- 50% owner of SAPA, world's largest provider of aluminium solutions

## • Employees in Norway

- 3,400

## • Investments

- NOK 22 billion 2001-2012

## • Research and development

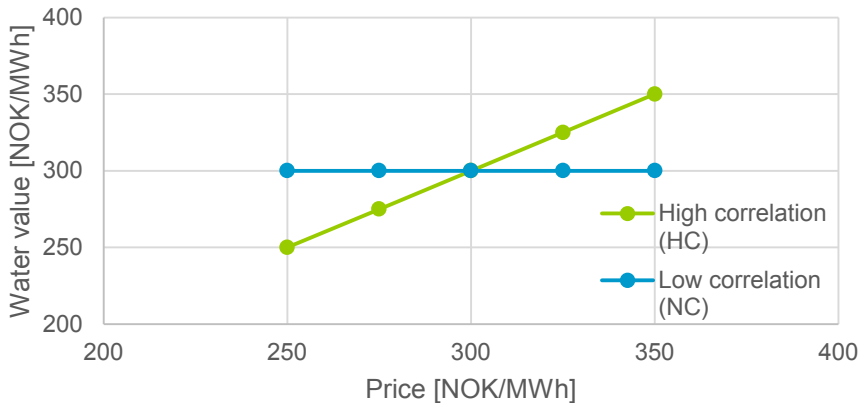
- Årdal, Sunddal, Karmøy, Porsgrunn, Oslo
- NTNU, SINTEF, UiO, IFE
- Annual R&D activity: NOK 350 million

# Background and motivation

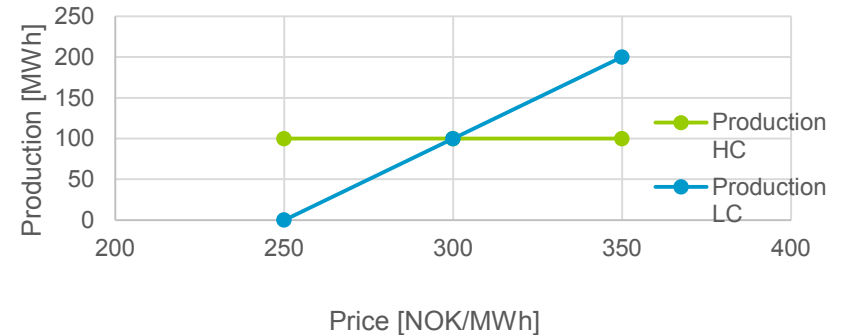
- SHOP results tend to stretch the limits for “preferred” dispatching
- Autocorrelation for price and inflow is not taken into account in coupling between SHOP and ProdRisk
  - Lower water values could be associated with spot prices delivering below prognosis.
- Multiscenario SHOP with potentially large variation in input prices / inflow requires more refined description of endpoint values.
  - Stochastic short term models such as SHARM could also be used for similar purpose
- “Soften” results and possibly avoid interference with tactical and other limitations.
  - Could potentially remove limitations which often have an effect on marginal costs representation
- Interpolate between the right sets of cuts to the right price and inflow

# Hypothesis : Taking price autocorrelation into account effect on watervalues will give more evenly distributed production

Watervalue and price correlation



Optimised production with high and low correlation



# Improved cut coupling between Prodrisk and SHOP

## Old set-up

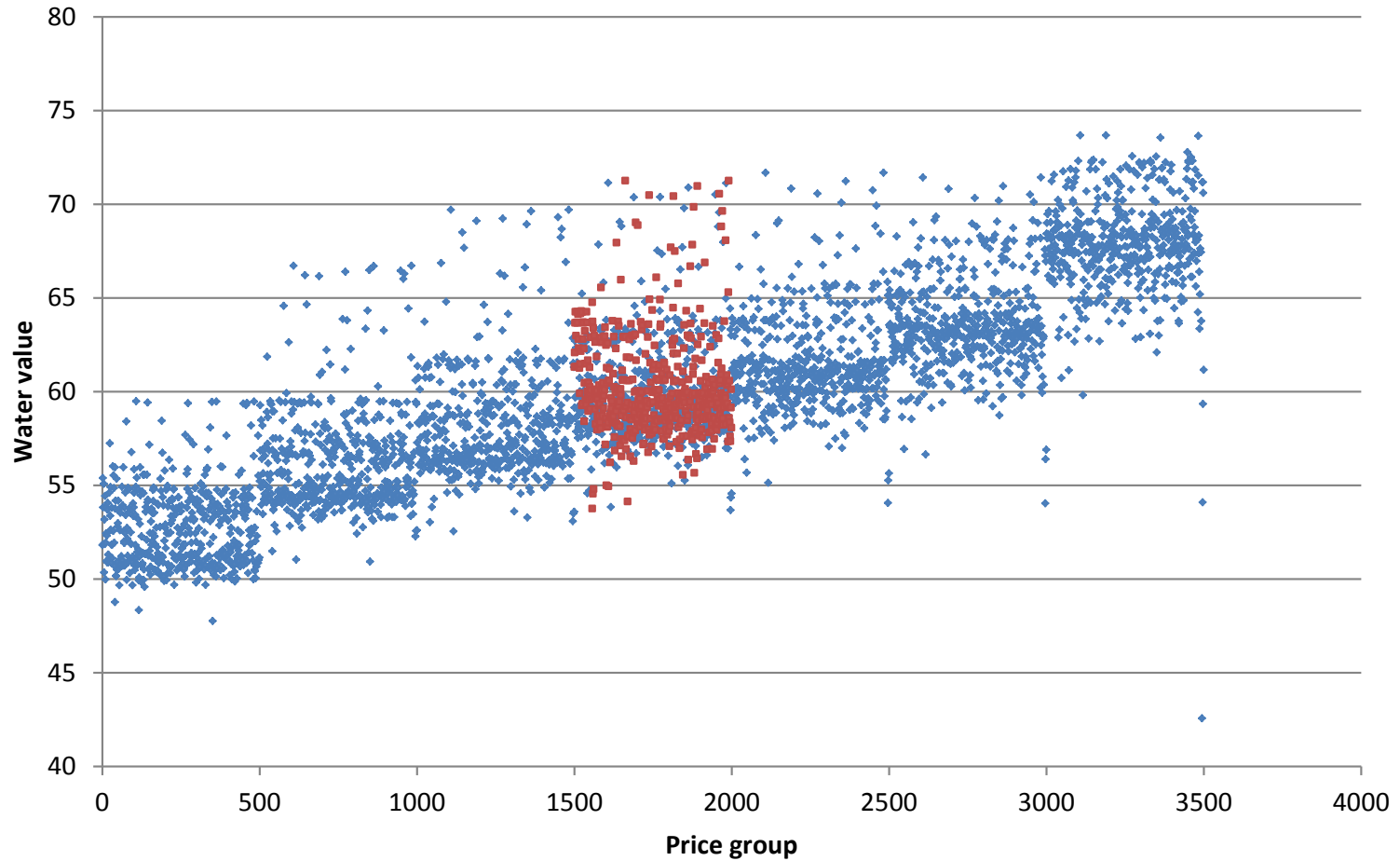
- Cuts in Prodrisk refer to prices in the PRISMOD file - typically this could be 7 price point per week
- In existing version, cuts used for SHOP refer to 1 selected price point and a fixed week given in Prodrisk
- Typically this could be price point 4 – middle price for present week and cuts referring to end of first or second week

## New set-up

- User selects weeks for listing of cuts in Prodrisk.cpar
- SHOP automatically select cuts that are associated with the price level and end-week in the input data.
- "Expected future income is automatically updated based on inflow data to SHOP
- The formula bellow illustrate the mathematical formulation of the solution from SINTEF

$$\begin{aligned}
 & \max \alpha \\
 & s. t. \alpha \leq b_i + \sum_r \kappa_{r,i} (V_r - V_{r,i}^*) \quad \Delta = \frac{\bar{p} - p_{down}}{p_{up} - p_{down}} \\
 & \max \Delta \alpha_{up} + (1 - \Delta) \alpha_{down} \\
 & s. t. \alpha_{up} \leq b_i + \sum_r \kappa_{r,i} (V_r - V_{r,i}^*) + \lambda_{s,i} (I_s - I_{s,i}^*) \\
 & \quad \alpha_{down} \leq b_i + \sum_r \kappa_{r,i} (V_r - V_{r,i}^*) + \lambda_{s,i} (I_s - I_{s,i}^*)
 \end{aligned}$$

# New cut coupling – input from ProdRisk





# New cut coupling – SHOP results

