

POWEL INFLOW

Optimal use of hydropower plants depends on detailed knowledge of water resources. Based on quantitative forecasts for precipitation and temperature, Powel Inflow is well suited to predict inflow. This information makes it possible to improve reservoir usage and thus allows for a more efficient and profitable operation of the hydropower system. Correct reservoir usage is vital for hydropower plants with low regulation capacity, when water level in the reservoir reaches highest or lowest regulated water level. Powel Inflow is also well suited in situations where the desire to increase net head must be balanced against the risk of increased spillage or flood.

Powel Inflow is a precipitation/run-off model that simulates the run-off process in a catchment area on the basis of temperature and precipitation. The model covers the main, hydrological processes, and calculates snow- and glacier accumulation and melting rate, evaporation, response from groundwater storage and inflow delays from soil moisture, lakes and rivers in the area. The model features a straightforward data structure and modest data requirements and calculates the hydrological processes in a catchment by using linear tanks. Snow, glacier, lake and soil moisture are distributed within the catchment elevation zones.

Important usage is:

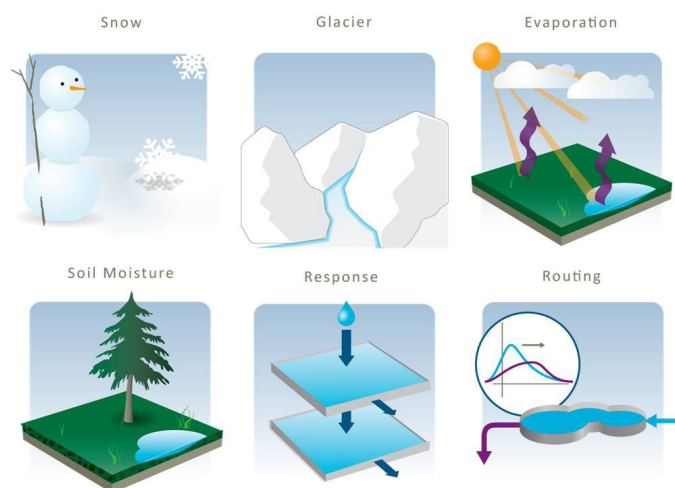
- Forecasting inflow
- Forecasting flood
- Climate development analysis

FACTS ABOUT POWEL INFLOW

Powel Inflow is based on the HBV-model developed by Sten Bergström from Hydrologiska Byrån for Vattenbalans in Sweden in the early 1970's, and has been tested and re-developed for over 30 years. Despite more advanced and sophisticated hydrological models, the HBV-model, in its simplicity, remains one of the fastest and best-suited models for inflow forecasting for hydropower generation and gives very good results. Furthermore, the HBV model is proven easy to update during daily operations.

The catchment is divided in ten elevation zones in order to provide for an accurate calculation of snow and glacier melt and accumulation. Weather forecast for a specific catchment is given for the model's middle height and distributed in the ten elevation zones, using calibrated precipitation rate and fixed or forecasted temperature lapse rate. In

order to update the model state conditions of snow, glacier, soil moisture and groundwater storage, measured data of temperature and area precipitation are needed. The run-off is corrected by an error function based on the trend in the difference between observed run-off and calculated run-off. Observed run-off is calculated by Powel Sim Water Management (see separate Fact Sheet) based on changes in reservoir level, power generation and spillway discharge, or calculated from measurements of discharge in fields.



Continuous data on temperature, inflow and precipitation for a period of time is also required in order to calibrate the model. The model contains a set of parameters which are calibrated to adjust the model to fit a certain catchment area.

METEOROLOGICAL FORECAST

Precipitation and temperature input:
Quantitative weather forecasts



Number of scenario's ≥ 1

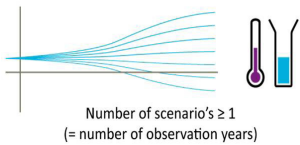
For short-term forecasts, normally 1-10 days ahead, quantitative forecasts on precipitation and temperature from a supplier of metrological services are usually used. Updated forecasts are automatically imported as time series several times per day. Temperature lapse rate can also be imported as a time series from a supplier of metrological services. The program can predict inflow for any time range.

Ensemble forecasts may also be used as input. This will result in a range of 50 different weather forecasts with the same probability and shows a spread of the inflow forecasts caused by the instability of the weather system. If Powel Inflow is used in combination with Powel Shop and Powel Sim, the power generation can be optimized and the consequences of different inflow scenarios may be simulated and analyzed in a model of the hydropower system.



HISTORICAL FORECAST

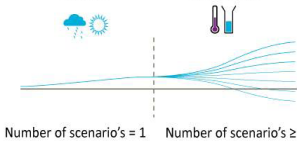
Precipitation and temperature input:
Historical records of observations from field stations.



COMBINED FORECAST

Precipitation and temperature input:

Quantative weather forecasts Historical records of observations



Historical, measured data of precipitation and temperature from the catchment area can also be used to produce long-term inflow forecasts. A simulation using a combination of short term weather forecasts and historical data is typically used as input to long term production planning and market analysis. This type of forecast may also be used for analysis regarding spring flood, climate development, new power stations etc.

Powel Inflow is a part of the Powel Smart Generation portfolio, which consists of integrated computation engines for forecasting, simulation and optimization, using Time Series Manager which automatically collect, validate, correct, scale, sum and store input and output data in the database to be used in the hydropower generation process.

The quality of the input data is verified through the system, and an alarm system is set. Predefined validation and correction methods are applied automatically, as the input data is stored in the database. The user can monitor the quality status of the input time series and the computed time series by using the Status Monitor, at any time during the process. If necessary, the data can be corrected manually.

