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Hydraulic design of smart storage for small alpine run-of-the-river hydropower plants

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ABSTRACT

With the increase of complexity of the electricity demand and integration of intermittent renewables, storage hydropower becomes one of the most flexible means to guarantee the reliability of the electrical supply. Hydropower schemes that have little or no storage are limited to providing energy to the system without the possibility of selecting the most adequate timing for the electrical grid or commercially, meaning that their energy production is perceived as having a lower market value.

Small hydropower is often operated as run-of-the-river. Recent plants benefiting from financial incentives (such as feed-in-tariffs to the deployment of renewable energies) must anticipate the market conditions they will face in the future once they are forced to conduct direct trading. This implies identifying functionalities will viable remuneration, such as dispatchable production (which needs some type of storage) including reactive power compensation (for small local grids or branches).

The ability to produce on demand depends directly of having or not storage at the headrace and tailrace of the hydropower scheme, or at least on the upstream side, allowing for intra-hourly, daily, weekly or monthly power regulation. Moving from a run-of-the-river operation mode to a hydropeaking mode may imply respecting river threshold conditions for safety and ecological safeguard, which may partially or totally reduce the economic interest of flexible production.

One possibility to introduce storage in small hydro schemes conceived for run-of-the-river operation is using part of the works for storage purposes in time windows when these works are not used for their original purpose. This correspond to adding functions to existing assets at reasonable cost with regards to the financial interest.

The case of study is the hydropower plant KW Gletsch-Oberwald located at Valais, Switzerland at 1755 masl in the upper Rhone River. This small HPP is basically a run-of-the-river plant (~4.6 MW) feed by the Gletsch glacier by one Tyrolean intake. Without an upstream reservoir, the weak point on this plant, it is the low or zero energy production in winter since the flow (≤ 0.4 m^3/s) can remain lower than the minimum possible discharge for one single jet of one single turbine (Qn= 0.25 m^3/s).

To overcome the low production in winter, one optimized solution presented by Morand (2017) was the ″Smart storage″ which consists of adding a temporary storage to the existed scheme when it is necessary (in this case, in winter using the existing settling basin as a reservoir) and accumulate the low discharge to produce energy at the well-paid-hours (peak demand).

The aim of this project is to test the efficiency of the ″Smart storage″ using a modelling approach to understand the flexibility of the actual hydraulic scheme of the plant under this operation and test some possible future scenarios taking into account the cost-benefit rate. These results will help develop some general instructions for the implementation of the smart operation system of other alpines HPPs.

The basic data will be provided by the Valais Forces FMV (project owner) and WSL, and will be also extracted from previous studies at LCH. This project is supported by LCH as a part of the Small-Flex project founded by the Swiss Competence Center for Energy Research – Supply of Electricity (SCCER-SOE) that focuses on innovative concepts to enhance the flexibility of hydropower production.

The operation of the hydropower scheme is modelled using a hydrological-hydraulic semi-distributed canvas called RS Minerve at sub-hourly time steps. On the hydrological side, the generation of runoff from net precipitation and glacier and snow melting will be compared with hydrological forecasts by the research partner WSL. Thanks to these features, the modelling scenarios will also include the test of the use of ″nowcasting″ for optimal management of the HPP and some possible modification to the real infrastructure (like increasing the volume of the additional storage underground or adding an up-stream storage).

On this catchment of 39 km^2, the hydrology is directly influenced by glacier and snowmelt (~50% of the catchment is cover by glaciers), rendering river discharge estimation quite dependent on the assessment of complex physical parameters such as the snow condition and likelihood for melting.

For the case of study, multiple elements must be evaluated like the hourly inflow rates, the geometry of the existed infrastructure, the characteristics of the two existed Pelton turbines, the ecological flow, and also the capacity of the operator to sell the energy in order to provide the project owner with a range of feasible possibilities to improve the operating flexibility and also a description of the problems that may be involved.

It is important to highlight that some additional projects are being carried out parallel to this project in the area of sediments production and real-time hydrological forecasts.

References

Morand G., Adam N., Manso P, Schleiss A. (2017). Augmentation de la flexibilité d’exploitation d’aménagements hydroélectriques à haute chute au fil de l’eau en Valais. SCCER-SoE Science Report