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Balancing hydropeaking mitigation and hydropower production

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Water storage has always been key for a country's development. However, time and experience have shown that despite its multiple benefits, storing water by building dams can have social and environmental undesired impacts. Consequently, nowadays, stricter operational regulations are being introduced and existing facilities are being assessed to reduce their impacts.

Positioned as one of the top European countries in hydropower production, Switzerland is continuously aiming at improving the performance of its hydroelectric facilities. One of the main impacts of hydropower operations on downstream river reaches is hydropeaking, resulting from highly fluctuating flows. In this context, based on the Swiss Federal Act on the Protection of Waters, hydropower operators are required to propose and put in place remediation measures for hydropeaking effects before the end of 2030. In addition, the national power-grid company (Swissgrid) has prepared a funding mechanism to reimburse the generated costs of the chosen measures.

In a first part, this study proposes a generic methodology that can be applied to hydroelectric schemes where hydropeaking is observed. Starting by the delimitation of the domain of study, the reference state of the facilities and the hydrological conditions are then established. Once the functioning of the system is well understood, different solutions to reduce hydropeaking are conceived and compared based on several selection criteria (e.g., feasibility, costs). Based on this comparison, adequate solutions are selected and designed. In a second part, the methodology is applied on a case study consisting of five hydropower facilities located in the Upper-Rhone Basin with a total annual production of about 500 GWh. In this confined system, two river reaches are affected by hydropeaking. Given the complexity and interconnection of the studied domain, numerous variants were defined but only two solutions were retained based on the selection criteria. The most adequate structural measures employed are (1) the rerouting of the flow and (2) the construction of compensation basins. The former has the advantage of eliminating hydropeaking effects while the latter provides more flexibility to the operations and therefore the possibility to reduce hydropeaking. Results reveal an interesting balance between hydropeaking mitigation and power production; while hydropeaking effects were eliminated, power production was preserved and even increased in most cases. Nevertheless, the complete mitigation of hydropeaking also means that the concerned river reach is left with only a residual flow. Therefore, hydropower operators should be careful to restore the rivers' natural conditions even after removing hydropeaking effects. Finally, a key parameter to improve the precision of hydropeaking studies is the availability of a dense network of discharge measuring stations with a high temporal resolution (e.g., time step of 5-10 minutes) in downstream reaches.